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Radiological Health Data

VOLUME V, NUMBER 4

APRIL 1964

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

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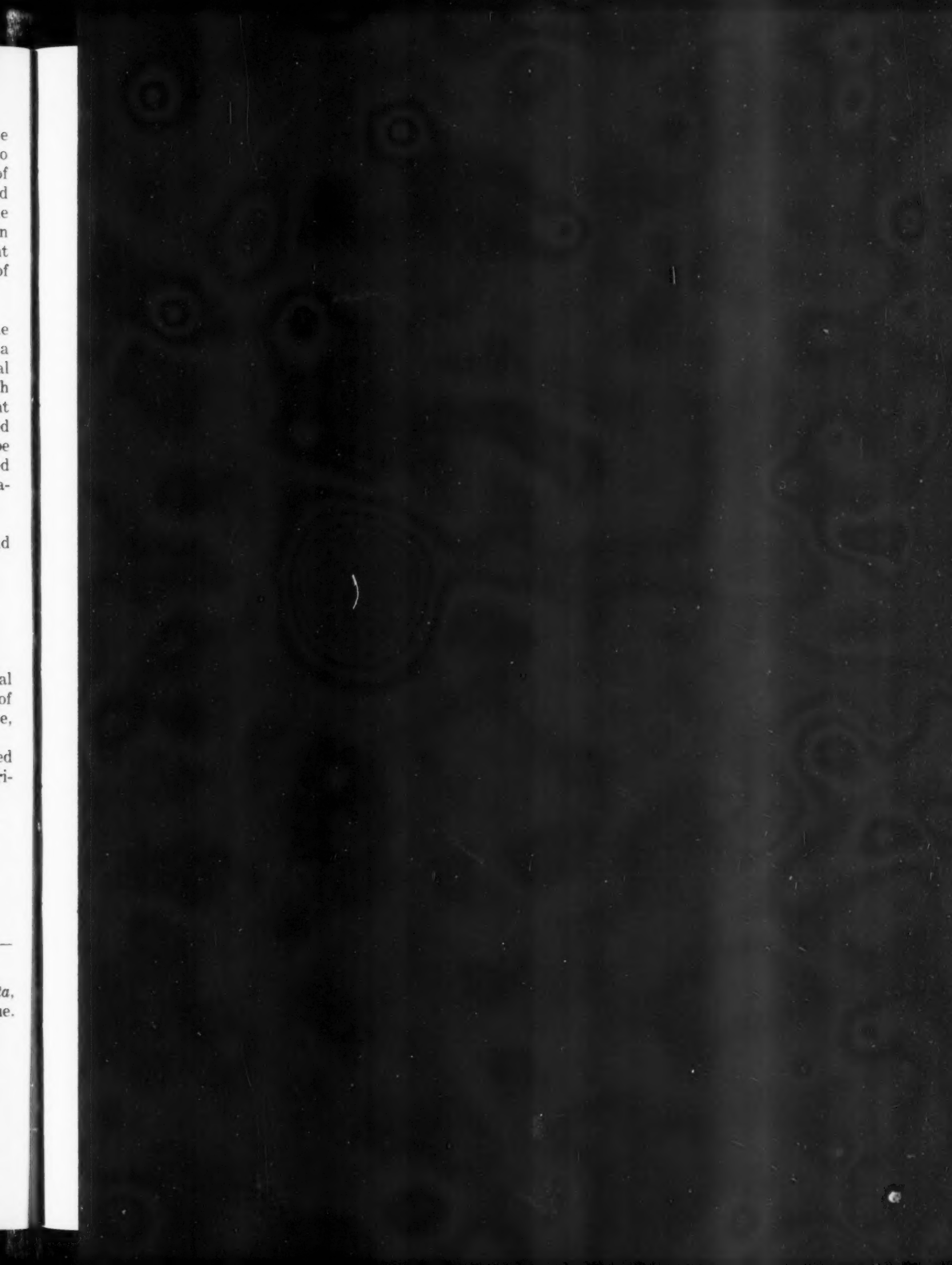

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Section I.—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Early indications of possible fission product activity fluctuations in various phases of the environment are detectable by continuous surveillance of gross beta activity in air and precipitation. This form of surveillance does not provide sufficient information for assessing human exposure due to fallout, but it forms a basis for an alerting system and is useful in determining when and where to conduct more intensive monitoring of radioactivity in food, milk, and water.

Gross beta concentrations in air are presented in reports from the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican National Commission of Nuclear Energy, and the Pan American Health Organization. December 1963 data from three networks were combined and are presented graphically by means of isograms on a map of North America (figure 6).

1. Radiation Surveillance Network, December 1963

Division of Radiological Health, Public Health Service

The Radiation Surveillance Network (RSN) is made up of 73 sampling stations distributed throughout the United States (see figure 1). Most of these stations are operated by State health department personnel.

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4 inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, and measured using a thin-window, gas-flow proportional counter, calibrated with a 38,700 pc Sr^{90}-Y^{90} standard.[1] Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. From the two counts, which are separated by the 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula[2] (*1*). The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*2*).

The December 1963 fission-product beta concentrations in surface air (extrapolated to the

[1] The Sr^{90}-Y^{90} source currently used as a standard was used from April 1962 to August 1963 as 40,000 pc total activity. Beginning with September 1963 data, the nominal activity of the standard was adjusted for decay (about 2½ percent per year) to 38,700 pc.

[2] $AT^{-1.2}=C$, where A is the activity, T is the time (in any time unit) after fission product formation, and C is a constant equal to the activity at T=1.

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, DECEMBER 1963

time of collection) are given in table 1. RSN data along with Canadian and Mexican air data are represented by isograms in figure 6.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m², C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, C, is determined by:

$$C = \frac{\Sigma D}{\Sigma P} \times 1000$$

The December 1963 average concentrations and total depositions are given in table 2.

Profiles

The profiles of the monthly average fission product beta activity of airborne particulates for each RSN station, covering the period of time from the formation of the network in 1956 to the end of 1960, were published in the July 1961 issue of *RHD*. In recent issues, several profiles have been updated each month. The last column of table 1 gives the issue of *RHD* having the most recent profile for each station. Eight profiles are updated through December 1963 in figure 2.

TABLE 1.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, DECEMBER 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average [a]	Last profile in *RHD*
Alaska:	Adak	26	0.91	<0.10	0.46	Nov 63
	Anchorage	26	1.4	<0.10	0.51	Jul 63
	Attu	31	0.95	<0.10	0.49	Dec 63
	Fairbanks	12	0.83	0.15	0.53	Aug 63
	Juneau	23	1.5	0.14	0.46	Sep 63
	Kodiak	21	1.1	<0.10	0.28	Oct 63
	Nome	17	0.79	<0.10	0.39	Feb 64
	Point Barrow	30	0.70	0.14	0.39	Jan 64
	St. Paul Island	26	1.0	0.21	0.52	Mar 64
Ariz:	Phoenix	28	3.3	0.75	1.6	Sep 63
Ark:	Little Rock	29	1.8	0.27	1.3	Sep 63
Calif:	Berkeley	20	1.4	0.28	0.70	Oct 63
	Los Angeles	21	2.6	0.72	1.6	Feb 64
C. Zone:	Ancon	15	0.59	0.17	0.33	Apr 64
Colo:	Denver	22	2.7	0.61	1.3	Nov 63
Conn:	Hartford	25	1.1	0.19	0.74	Oct 63
Del:	Dover	18	0.92	0.20	0.62	Aug 63
D. C:	Washington	31	1.2	0.13	0.67	Apr 64
Fla:	Jacksonville	25	1.9	0.47	1.3	Oct 63
	Miami	26	4.4	0.29	1.7	Feb 64
Ga:	Atlanta	18	1.1	0.30	0.67	Jul 63
Guam:	Agana	28	1.1	<0.10	0.41	Apr 64
Hawaii:	Honolulu	25	2.2	0.16	0.60	Feb 64
Idaho:	Boise	24	1.6	0.20	0.86	Dec 63
Ill:	Springfield	16	1.2	0.32	0.64	Mar 64
Ind:	Indianapolis	26	1.3	0.34	0.72	Jul 63
Iowa:	Iowa City	26	1.4	0.30	0.66	Jan 64
Kans:	Topeka	24	1.8	0.36	0.89	Jul 63
Ky:	Frankfort	30	1.4	0.30	0.79	Feb 64
La:	New Orleans	25	1.8	<0.10	1.1	Mar 64
Maine:	Augusta	30	1.6	0.28	0.96	Mar 64
	Presque Isle	27	1.0	0.18	0.66	Nov 63
Md:	Baltimore	21	1.1	0.15	0.61	Nov 63
	Rockville	16	1.5	0.23	1.0	Mar 64
Mass:	Lawrence	25	1.5	0.28	0.99	Aug 63
	Winchester	23	1.4	0.22	0.80	Apr 64
Mich:	Lansing	29	1.7	0.30	0.91	Feb 64
Minn:	Minneapolis	25	1.1	0.26	0.61	Mar 64
Miss:	Jackson	23	1.6	<0.10	0.90	Apr 64
	Pascagoula	11	2.1	<0.10	1.2	Dec 63
Mo:	Jefferson City	25	1.4	0.37	0.82	Nov 63
Mont:	Helena	24	2.0	0.30	1.0	Nov 63
Nebr:	Lincoln	5	0.67	0.44	0.57	Apr 64
Nev:	Las Vegas	23	4.2	0.70	2.3	Jul 63
N.H:	Concord	19	1.9	0.26	1.1	Feb 64
N.J:	Trenton	24	1.8	0.11	0.71	Apr 64
N. Mex:	Santa Fe	29	2.8	0.78	0.71	Dec 63
N.Y:	Albany	20	1.9	0.14	0.85	Jul 63
	Buffalo	0	—	—	—	Nov 63
	New York	21	1.1	0.16	0.72	Dec 63
N.C:	Gastonia	23	1.8	0.33	0.98	Jan 64
N. Dak:	Bismarck	22	1.5	0.33	0.78	Feb 64
Ohio:	Cincinnati	20	0.88	<0.10	0.57	Aug 63
	Columbus	29	1.4	0.26	0.70	Apr 64
	Painesville	31	2.0	0.30	0.96	Oct 63
Okla:	Oklahoma City	29	1.6	0.33	0.99	Apr 64
	Ponca City	22	0.95	0.31	0.67	Oct 63
Ore:	Portland	26	2.8	0.33	1.2	Oct 63
Pa:	Harrisburg	23	1.2	<0.10	0.64	Jan 64
P.R:	San Juan	25	0.81	0.12	0.37	Mar 64
R.I:	Providence	23	1.2	0.29	0.80	Jan 64
S.C:	Columbia	22	1.3	<0.10	0.69	Dec 63
S. Dak:	Pierre	29	1.3	0.31	0.70	Sep 63
Tenn:	Nashville	31	1.9	0.30	0.93	Jan 64
Tex:	Austin	23	2.6	0.54	1.4	Aug 63
	El Paso	23	2.7	0.62	1.5	Jan 64
Utah:	Salt Lake City	30	1.7	0.54	1.1	Aug 63
Vt:	Barre	29	2.0	0.19	1.0	Sep 63
Va:	Richmond	26	0.96	<0.10	0.56	Sep 63
Wash:	Seattle	24	1.6	0.16	0.62	Jul 63
W. Va:	Charleston	22	1.1	0.24	0.67	Dec 63
Wisc:	Madison	29	1.1	0.18	0.77	Sep 63
Wyo:	Cheyenne	24	2.3	0.59	1.0	Aug 63
Network summary		1,719	4.4	<0.10	0.85	

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10% of the average, a less-than sign is placed in front of the average.

TABLE 2. GROSS BETA ACTIVITY IN PRECIPITATION, DECEMBER 1963

Station location		Average concentration [a] (pc/liter)	Total deposition [a] (nc/m²)
Alaska:	Anchorage	290	3.2
	Fairbanks	640	3.9
	Juneau	330	47
Ark:	Little Rock	240	13
Calif:	Berkeley	500	7.5
	Los Angeles	[b]	[b]
Colo:	Denver	[b]	[b]
Conn:	Hartford	320	21
D.C:	Washington	500	14
Fla:	Jacksonville	310	14
	Miami	250	26
Ga:	Atlanta	510	2.3
Hawaii:	Honolulu	200	2.0
Idaho:	Boise	[b]	[b]
Ill:	Springfield	[b]	[b]
Ind:	Indianapolis	320	6.0
Iowa:	Iowa City	570	10
Kans:	Topeka	470	13
Ky:	Frankfort	440	6.1
La:	New Orleans	250	32
Maine:	Augusta	380	19
	Presque Isle	[b]	[b]
Md:	Baltimore	490	4.9
Mass:	Lawrence	460	26
	Winchester	470	37
Mich:	Lansing	1,580	28
Minn:	Minneapolis	240	4.0
Miss:	Jackson	270	23
Mo:	Jefferson City	480	5.8
Mont:	Helena	630	18
Nebr:	Lincoln	[b]	[b]
Nev:	Las Vegas	[b]	[b]
N.J:	Trenton	260	3.9
N. Mex:	Santa Fe	890	2.6
N.Y:	Albany	270	12
N.C:	Gastonia	230	16
N. Dak:	Bismarck	610	12
Ohio:	Columbus	530	11
	Painesville	620	24
Okla:	Oklahoma City	[b]	[b]
	Ponca City	640	3.6
Ore:	Portland	290	20
Pa:	Harrisburg	390	4.4
P.R:	San Juan	200	4.8
R.I:	Providence	400	27
S.C:	Columbia	230	26
S. Dak:	Pierre	200	4.2
Tenn:	Nashville	510	19
Tex:	Austin	[b]	[b]
	El Paso	[b]	[b]
Utah:	Salt Lake City	560	8.3
Vt:	Barre	560	36
Va:	Richmond	240	16
Wash:	Seattle	360	28
W. Va:	Charleston	400	15
Wisc:	Madison	740	10
Wyo:	Cheyenne	1,300	10

[a] The minimum concentration reported for a single sample is 200 pc/liter. If the individual sample has a concentration of <200 pc/liter, the deposition for that sample is calculated by D = <0.2 P in nc/m² (see text). A less-than sign (<) is used with the monthly total deposition whenever the sum of the individual less-than values represents more than 10 percent of the total. The monthly average concentration is then calculated as described in text, retaining the less-than sign when used with the total deposition.

[b] No evaporated sample received.

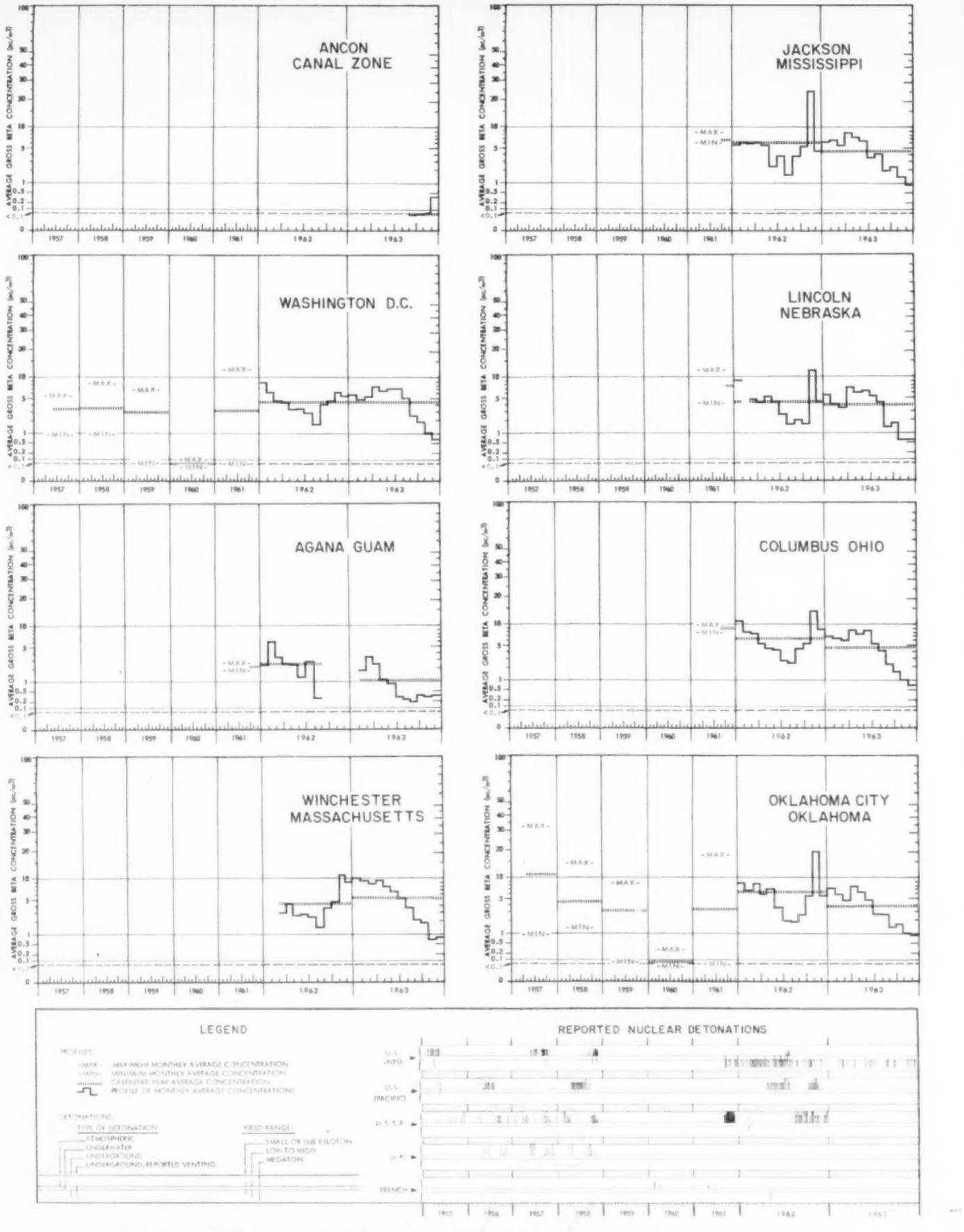

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1957—DECEMBER 1963

2. National Air Sampling Network, Fourth Quarter and Annual Summary, 1963

Division of Air Pollution,
Public Health Service

The need for basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. These analyses aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors associated with air quality.

Gross Beta Activity in Air

NASN stations (see figure 3) are manned by cooperating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, there are 240 sampling stations in all in the NASN network, of which 175 are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are then sent for analysis to the Network laboratory in Cincinnati, Ohio. Fourth quarter and annual summary 1963 data appear in tables 3 and 4.

Gross Beta Activity in Precipitation

The present reporting of gross beta activity in precipitation originated in 1959 when a precipitation collection and analysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio, and the National Air Sampling Network. Precipitation is collected at 29 stations located at airports and Weather Bureau offices, and monthly composite

FIGURE 3.—NATIONAL AIR SAMPLING NETWORK SAMPLING STATIONS, 1963

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, FOURTH QUARTER, 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	6	3.5	0.7	2.2
	Huntsville	6	2.5	0.4	1.6
	Montgomery	6	3.8	1.2	2.4
Alaska:	Anchorage	6	2.4	<0.1	1.0
	Pt. Woronzof*	4	2.6	0.4	1.2
Ariz:	Grand Canyon Pk.*	6	2.9	1.4	2.3
	Maricopa County*	6	2.8	0.9	2.3
	Phoenix	6	2.4	0.6	1.5
	Tucson	6	2.6	1.9	2.2
Ark:	Little Rock	5	3.0	0.8	1.8
	Montgomery Co.*	6	2.7	1.4	2.0
Calif:	Berkeley	6	1.7	0.5	1.2
	Glendale	6	2.6	1.1	1.8
	Humboldt County*	5	2.4	0.5	1.6
	Long Beach	7	4.5	1.0	2.1
	Los Angeles	6	2.2	1.0	1.7
	Monterey	5	3.1	0.8	1.9
	Oakland	6	2.8	0.8	1.7
	San Bernardino	5	2.8	1.0	2.2
	San Diego	6	2.3	1.1	1.8
	San Francisco	6	2.1	0.6	1.4
	San Jose	6	3.3	0.9	1.7
	Santa Barbara	6	2.1	0.9	1.6
	Stockton	6	4.2	0.4	2.0
Colo:	Denver	6	3.1	1.2	1.9
	Montezuma County*	5	2.8	1.1	1.7
	Pueblo	6	2.9	1.1	1.7
Conn:	Hartford	6	3.1	0.2	1.9
	New Britain	6	4.0	0.2	2.0
	New Haven	5	3.7	0.2	2.0
	Norwich	6	3.3	0.2	1.7
	Waterbury	6	3.2	0.2	1.4
Del:	Kent County*	5	2.6	1.0	2.1
	Wilmington	7	2.6	0.2	1.8
D.C:	Washington	6	2.2	0.2	1.5
Fla:	Florida Keys*	6	3.7	1.4	2.1
	Miami	7	3.3	1.6	2.3
	Orlando	5	2.7	1.3	1.8
	St. Petersburg	7	4.7	0.2	2.2
	Tampa	6	3.5	1.3	2.3
Ga:	Atlanta	7	3.3	0.5	1.9
	Augusta	6	3.2	0.6	2.0
	Savannah	6	2.1	1.1	1.6
Hawaii:	Honolulu	6	1.8	0.5	0.9
	Kahaluu*	6	2.2	0.5	1.1
Idaho:	Boise	6	4.4	0.7	2.0
	Butte County*	6	4.1	0.9	2.1
Ill:	Chicago	7	4.7	0.6	1.7
	East St. Louis	5	4.6	0.7	1.8
	Joliet	6	3.7	0.2	1.2
	North Chicago	5	3.8	0.6	1.4
	Rockford	6	3.8	0.7	1.5
Ind:	East Chicago	5	5.8	0.6	2.4
	Hammond	6	3.7	0.7	1.4
	Indianapolis	6	8.4	0.8	3.1
	Parke County*	5	3.7	0.4	1.6
	Muncie	6	3.7	0.5	1.8
	South Bend	6	3.6	0.5	1.3
	Terre Haute	6	3.4	0.8	1.5
Iowa:	Cedar Rapids	6	4.6	0.7	1.6
	Davenport	6	1.6	0.5	0.9
	Delaware County*	6	3.7	0.4	1.4
	Des Moines	6	4.2	0.4	1.5
Kans:	Topeka	6	3.8	0.9	1.7
	Wichita	6	4.4	1.2	2.1
Ky:	Lexington	6	3.2	0.5	1.8
	Louisville	4	3.3	0.3	1.6
La:	New Orleans	6	4.1	1.7	2.3
	Shreveport	6	3.3	1.7	2.3
Maine:	Acadia Nat'l. Park*	6	2.3	0.9	1.7
	Portland	6	2.7	0.5	1.6
Md:	Baltimore	6	2.5	0.2	1.3
	Calvert County*	6	2.7	0.3	1.7
	Cumberland	6	2.6	0.2	1.4
Mass:	Boston	6	3.0	0.4	1.6
	Lowell	6	3.9	0.3	2.2
	Worcester	6	2.8	0.2	1.5
Mich:	Dearborn	7	3.5	0.7	1.7
	Detroit	6	3.0	0.5	1.5
	Flint	6	3.9	0.6	1.5
	Grand Rapids	7	4.2	0.4	1.5
	Jackson	6	3.8	0.6	1.6
	Muskegon	6	3.6	0.4	1.3
Minn:	Duluth	6	4.2	0.3	1.7
	Minneapolis	6	3.4	0.4	1.2
	St. Paul	6	3.9	0.4	1.4
Miss:	Jackson	7	3.4	1.3	2.4
	Jackson County*	4	3.3	1.8	2.5
Mo:	Kansas City	6	4.1	0.9	1.8
	Shannon County*	6	4.3	1.4	2.4
	St. Louis	6	2.9	0.5	1.1
Mont:	Glacier Nat'l. Park*	5	2.3	0.5	1.4
	Helena	6	4.0	0.6	1.8
Nebr:	Omaha	6	4.7	0.6	1.8
	Thomas County*	6	5.3	0.8	2.4
Nev:	Las Vegas	5	2.9	1.3	2.1
	Reno	7	6.9	0.4	3.0
	White Pine Co.*	7	4.9	1.1	2.3
N.H:	Coos County*	6	2.0	0.2	1.2
N.J:	Atlantic City	6	4.0	0.2	2.0
	Bayonne	6	3.5	1.2	1.8
	Hamilton	6	3.4	0.2	1.8
	Jersey City	6	3.9	0.2	1.7
	Newark	6	3.6	0.8	1.9
	Paterson	7	2.5	0.2	1.6
N.M:	Albuquerque	6	3.0	1.0	1.9
N.Y:	Cape Vincent*	6	2.8	0.2	1.4
	Massena	6	2.8	0.4	1.7
	New York	5	4.3	0.2	2.1
	Niagara Falls	6	2.9	0.1	1.2
	Rochester	5	2.9	0.3	1.7
	Troy	6	2.9	0.2	1.7
N.C:	Cape Hatteras*	7	3.3	0.5	2.0
	Charlotte	6	2.4	0.6	1.6
	Durham	7	1.9	0.2	0.9
	Greensboro	6	2.4	0.3	1.5
	Raleigh	5	2.8	1.7	2.2
N. Dak:	Bismarck	6	3.4	0.8	1.4
	Ward County*	5	2.4	0.7	1.3
Ohio:	Akron	5	3.0	0.3	1.5
	Canton	6	3.5	0.2	1.8
	Cincinnati	6	2.2	0.8	1.6
	Cleveland	6	3.7	0.4	2.1
	Columbus	6	3.0	0.6	1.5
	Dayton	6	3.2	0.7	1.7
	Hamilton	6	2.6	0.7	1.6
	Toledo	6	4.0	0.4	2.1
	Youngstown	6	3.9	0.3	1.8
Okla:	Cherokee County*	5	2.6	0.9	1.8
	Oklahoma City	3	3.3	2.1	2.7
	Tulsa	6	2.6	1.3	1.9
Ore:	Curry County*	3	0.8	0.2	0.5
	Eugene	5	1.7	0.3	1.1
	Medford	6	4.4	0.4	1.6
	Portland	7	2.8	0.7	1.4
Pa:	Allentown	7	2.1	0.1	1.2
	Altoona	6	2.4	0.3	1.5
	Bethlehem	6	2.9	0.9	2.1
	Clarion County*	5	2.5	0.6	1.3
	Erie	6	3.3	0.4	1.8
	Johnstown	6	2.2	0.9	1.7
	Philadelphia	7	2.9	0.2	1.6
	Pittsburgh	6	2.6	0.3	1.5
	Scranton	6	2.4	0.2	1.5
	York	6	2.9	1.4	2.2
R. I:	East Providence	6	3.2	0.3	1.6
	Providence	5	3.3	1.0	2.1
	Washington Co.*	6	3.3	0.3	1.8
S. C:	Charleston	6	3.2	0.6	1.9
	Columbia	5	1.9	0.5	1.5
	Richland County*	6	3.1	1.4	2.0
S. Dak:	Black Hills*	7	3.4	0.9	1.8
	Sioux Falls	5	4.4	0.2	1.3
Tenn:	Chattanooga	4	3.6	1.2	2.4
	Knoxville	6	3.1	0.3	1.6
	Memphis	4	3.3	1.4	2.4
	Nashville	6	2.8	0.5	1.7
Tex:	Aransas County*	6	3.3	0.8	2.0
	Austin	6	2.6	0.7	1.8
	Beaumont	4	3.4	1.5	2.3
	Dallas	6	2.7	1.2	1.7
	Galveston	5	4.7	2.0	2.9
	Houston	5	3.7	1.3	2.0
	Odessa	7	3.6	0.5	2.0
	San Antonio	6	2.5	0.5	1.8
	Tyler	6	5.3	1.4	2.6
Utah:	Salt Lake City	6	4.2	1.3	2.2
Vt:	Burlington	6	2.5	0.3	1.3
	Orange County*	6	2.3	0.2	1.3
Va:	Hampton	6	2.9	0.7	1.8
	Lynchburg	3	1.8	0.3	1.0
	Norfolk	6	3.5	0.5	1.8
	Portsmouth	6	2.0	0.3	1.3
	Richmond	6	2.8	0.6	1.7
	Roanoke	6	3.8	0.3	1.7
	Shenandoah Park*	6	3.1	0.2	1.7
Wash:	Clallam County*	4	2.6	0.9	1.6
	Seattle	6	2.8	0.5	1.4
	Spokane	5	1.4	0.6	1.1
W. Va:	Charleston	6	3.0	0.4	1.7
	Wheeling	3	2.6	1.3	1.8
Wis:	Door County*	6	2.0	1.0	1.5
	Kenosha	5	3.7	0.7	1.4
	Madison	6	4.6	0.5	1.5
	Milwaukee	6	2.5	0.5	1.2
Wyo:	Cheyenne	6	3.1	0.7	1.8
	Yellowstone Park*	5	4.9	0.7	2.0
Network summary		1079	8.4	<0.1	1.7

* Nonurban station.

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, ANNUAL SUMMARY, 1963

[Concentrations in pc/m³]

Stations		Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	26	15.8	0.2	7.2
	Huntsville	25	19.8	0.4	7.9
	Montgomery	26	16.3	1.2	7.2
Alaska:	Anchorage	26	17.6	<0.1	4.5
	Pt. Woronzof[a]	24	19.5	0.3	5.4
Ariz:	Grand Canyon Pk.[a]	26	47.2	1.1	11.3
	Maricopa County[a]	26	29.7	0.9	10.8
	Phoenix	25	26.7	0.6	9.3
	Tucson	25	30.4	0.7	9.5
Ark:	Little Rock	18	14.3	0.8	6.4
	Montgomery County[a]	24	19.2	1.4	6.4
Calif:	Berkeley	20	24.4	0.5	4.2
	Glendale	26	32.2	1.1	8.9
	Humboldt County[a]	22	24.6	0.3	3.9
	Long Beach	25	24.6	1.0	7.8
	Los Angeles	26	30.0	1.0	7.2
	Monterey	20	10.1	0.8	4.3
	Oakland	25	27.5	0.8	6.1
	San Bernardino	23	25.2	1.0	11.2
	San Diego	25	29.7	1.1	7.1
	San Francisco	26	25.6	0.6	5.3
	San Jose	26	29.6	0.9	5.8
	Santa Barbara	25	31.4	0.9	6.7
	Stockton	26	12.4	0.4	5.7
Colo:	Denver	25	34.6	1.2	9.0
	Montezuma County[a]	25	27.6	1.1	9.2
	Pueblo	25	29.6	1.1	8.7
Conn:	Hartford	26	23.2	0.2	6.3
	New Britain	22	15.4	0.2	5.3
	New Haven	25	21.6	0.2	6.6
	Norwich	26	30.0	0.2	7.3
	Waterbury	25	14.9	0.2	4.8
Del:	Kent County[a]	19	12.0	1.0	5.3
	Wilmington	25	16.5	0.2	6.3
D.C:	Washington	25	28.5	0.2	7.4
Fla:	Florida Keys[a]	25	18.6	0.4	7.1
	Miami	25	23.4	1.2	8.0
	Orlando	22	18.7	0.4	6.3
	St. Petersburg	26	21.6	0.2	6.4
	Tampa	23	18.5	0.7	6.1
Ga:	Atlanta	26	16.0	0.1	6.6
	Augusta	25	17.9	0.6	6.6
	Savannah	26	19.2	0.7	6.2
Hawaii:	Honolulu	26	12.4	0.5	3.6
	Kahaluu[a]	26	12.8	0.5	4.2
Idaho:	Boise	23	26.5	0.7	8.7
	Butte County[a]	25	30.0	0.9	10.8
Ill:	Chicago	24	16.4	0.6	6.1
	East St. Louis	23	28.5	0.7	7.6
	Joliet	26	19.1	0.2	6.7
	North Chicago	23	27.3	0.6	7.9
	Rockford	23	18.2	0.7	6.7
Ind:	East Chicago	19	16.8	0.4	5.4
	Hammond	26	16.3	0.7	6.7
	Indianapolis	23	20.0	0.8	8.1
	Parke County[a]	25	17.3	0.4	8.0
	Muncie	25	20.7	0.5	7.4
	South Bend	26	19.4	0.5	7.2
	Terre Haute	24	22.6	0.8	8.0
Iowa:	Cedar Rapids	26	14.9	0.7	6.7
	Davenport	25	49.3	0.5	7.4
	Delaware County[a]	25	15.0	0.4	5.7
	Des Moines	26	22.6	0.4	6.0
Kans:	Topeka	26	14.0	0.9	5.7
	Wichita	26	19.0	1.2	7.1
Ky:	Lexington	24	16.5	0.5	7.1
	Louisville	19	19.1	0.3	7.7
La:	New Orleans	26	17.5	1.4	6.7
	Shreveport	22	17.8	1.5	6.9
Maine:	Acadia Nat'l. Park[a]	22	12.0	0.9	4.1
	Portland	25	15.5	0.5	5.8
Md:	Baltimore	26	15.6	0.2	6.0
	Calvert County[a]	26	17.0	0.3	6.7
	Cumberland	26	19.6	0.2	6.6
Mass:	Boston	22	16.8	0.4	5.4
	Lowell	26	29.6	0.3	9.7
	Worcester	26	19.3	0.2	6.2
Mich:	Dearborn	26	21.3	0.7	7.0
	Detroit	26	17.2	0.5	6.0
	Flint	23	17.8	0.6	5.8
	Grand Rapids	24	17.4	0.4	6.2
	Jackson	26	20.4	0.6	7.7
	Muskegon	25	17.8	0.4	5.9
Minn:	Duluth	25	18.3	0.3	5.8
	Minneapolis	26	16.4	0.4	6.2
	St. Paul	26	20.9	0.4	7.1
Miss:	Jackson	23	18.4	1.3	7.6
	Jackson County[a]	19	18.0	1.0	6.4
Mo:	Kansas City	24	17.2	0.7	6.6
	Shannon County[a]	22	19.6	1.3	8.1
	St. Louis	25	17.8	0.5	7.0
Mont:	Glacier Nat'l. Park[a]	20	19.2	0.5	5.9
	Helena	26	22.6	0.6	7.8
Nebr:	Omaha	25	13.7	0.6	6.5
	Thomas County[a]	25	20.4	0.8	7.6
Nev:	Las Vegas	22	34.1	1.0	12.5
	Reno	24	18.6	0.4	9.0
	White Pine Co.[a]	25	36.5	1.1	10.3
N. H:	Coos County[a]	19	15.3	0.2	6.9
N. J:	Atlantic City	25	14.6	0.2	6.3
	Bayonne	24	19.8	1.2	5.6
	Hamilton	23	16.6	0.2	6.4
	Jersey City	23	32.8	0.2	6.0
	Newark	26	18.0	0.8	6.3
	Paterson	26	22.0	0.2	6.2
N. Mex:	Albuquerque	25	25.6	0.8	7.8
	Colfax County[a]	18	38.4	0.4	12.1
N. Y:	Cape Vincent[a]	25	20.3	0.2	6.4
	Massena	26	17.9	0.4	6.1
	New York	25	24.2	0.2	8.6
	Niagara Falls	26	17.8	0.1	6.8
	Rochester	25	16.0	0.3	6.1
	Troy	21	15.7	0.2	5.4
N. C:	Cape Hatteras[a]	24	16.7	0.5	6.6
	Charlotte	26	18.6	0.6	7.6
	Durham	26	19.7	0.2	6.8
	Greensboro	26	26.0	0.3	7.9
	Raleigh	24	18.5	1.5	6.1
N. Dak:	Bismarck	26	17.6	0.8	6.3
	Ward County[a]	24	16.0	0.7	6.5
Ohio:	Akron	25	16.9	0.3	6.9
	Canton	26	14.4	0.2	6.4
	Cincinnati	26	17.6	0.8	7.5
	Cleveland	24	18.8	0.4	7.2
	Columbus	26	16.4	0.6	7.0
	Dayton	26	18.4	0.7	7.5
	Hamilton	26	19.4	0.7	8.0
	Toledo	26	19.3	0.4	7.1
	Youngstown	26	15.5	0.3	6.7
Okla:	Cherokee County[a]	24	16.2	0.9	6.3
	Oklahoma City	19	22.5	1.9	6.9
	Tulsa	25	18.4	1.3	7.1
Ore:	Curry County[a]	20	10.8	0.2	3.7
	Eugene	21	24.1	0.3	4.3
	Medford	24	9.2	0.4	3.7
	Portland	23	22.0	0.7	4.4
Pa:	Allentown	26	14.2	0.1	4.9
	Altoona	22	14.4	0.3	6.8
	Bethlehem	26	15.7	0.9	7.4
	Clarion County[a]	21	15.4	0.6	5.7
	Erie	25	20.7	0.4	7.2
	Johnstown	23	13.0	0.9	6.0
	Philadelphia	25	15.6	0.2	6.3
	Pittsburgh	25	15.7	0.3	6.4
	Scranton	26	24.1	0.2	6.0
	York	26	22.0	1.4	7.8
R. I:	East Providence	25	16.8	0.3	6.5
	Providence	21	17.1	1.0	6.1
	Washington Co.[a]	26	24.6	0.3	7.0
S. C:	Charleston	25	23.8	0.6	7.6
	Columbia	23	13.2	0.5	5.7
	Richland County[a]	24	25.6	1.4	9.6
S. Dak:	Black Hills[a]	26	25.1	0.9	8.2
	Sioux Falls	23	13.5	0.2	6.2
Tenn:	Chattanooga	24	18.4	1.2	7.6
	Knoxville	25	14.5	0.3	6.6
	Memphis	23	17.5	1.4	8.5
	Nashville	26	21.0	0.5	7.6
Tex:	Aransas County[a]	24	17.5	0.8	6.1
	Austin	26	22.2	0.7	7.3
	Beaumont	16	21.5	1.1	5.9
	Dallas	23	16.6	1.1	5.6
	Galveston	23	15.0	1.2	6.2
	Houston	22	16.7	1.3	6.7
	Odessa	25	19.0	0.5	6.5
	San Antonio	24	21.1	0.5	6.6
	Tyler	26	22.8	1.4	7.4
Utah:	Salt Lake City	26	26.4	1.3	10.3
Vt:	Burlington	21	18.0	0.1	6.2
	Orange County[a]	26	17.6	0.2	6.3
Va:	Hampton	26	12.2	0.7	5.5
	Lynchburg	21	21.3	0.3	7.8
	Norfolk	25	15.3	0.5	6.8
	Portsmouth	25	13.1	0.3	5.9
	Richmond	25	13.6	0.6	6.3
	Roanoke	21	18.1	0.3	8.2
	Shenandoah Park[a]	26	20.3	0.2	7.2
Wash:	Clallam County[a]	19	10.0	0.9	4.0
	Seattle	26	23.0	0.5	4.1
	Spokane	24	19.6	0.6	6.9
W. Va:	Charleston	26	21.4	0.4	7.4
	Wheeling	20	21.3	1.3	9.0
Wis:	Door County	24	17.8	1.0	7.1
	Kenosha	25	17.6	0.7	6.9
	Madison	26	18.7	0.5	6.8
	Milwaukee	26	16.0	0.5	6.2
Wyo:	Cheyenne	24	41.6	0.7	10.3
	Yellowstone Park[a]	25	24.6	0.7	10.4
Network summary		4,562	49.3	<0.1	6.9

[a] Nonurban station.

TABLE 5.—FISSION PRODUCT BETA ACTIVITY IN PRECIPITATION—NASN, FOURTH QUARTER, 1963

Station		October		November		December	
		pc/liter	nc/m²	pc/liter	nc/m²	pc/liter	nc/m²
Ala:	Montgomery	—	—	83	5	211	25
Fla:	Tampa	—	—	59	8	271	12
La:	Lake Charles	—	—	45	4	98	6
Maine:	Caribou	560	29	87	10	—	—
Mass:	Nantucket	220	17	88	6	196	17
Mich:	Sault Ste. Marie	—	—	250	17	413	21
N. Y.:	Albany	—	—	177	17	405	19
N. C.:	Hatteras	92	12	69	5	252	23
Pa:	Philadelphia	—	—	127	19	392	18
S. C.:	Charleston	290	13	78	10	100	8
	Greenville	—	—	104	11	204	20
Tenn:	Nashville	—	—	125	5	152	9
Texas:	Brownsville	—	—	—	—	369	19
	San Angelo	—	—	84	4	—	—
Va:	Sterling	—	—	62	10	224	17
Wash:	Tatoosh	210	54	105	24	232	51

samples are forwarded to the Cincinnati laboratory for analysis.

The laboratory analyzes these samples for total solids and for a large number of metals and nonmetals. In addition, each sample is analyzed for fission product gross beta radioactivity if a sufficient volume of precipitation remains after chemical analyses have been made. Precipitation data for the fourth quarter 1963 are presented in table 5.

3. Canadian Air Monitoring Program,[3] December 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program, the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four collection stations are located at airports (see figure 4), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3-7*).

[3] Data from *Radiation Protection Programs*, *2*:11-24, Radiation Protection Division, Canadian Department of National Health and Welfare (January 1964).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter system, calibrated with a Sr^{90}-Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for December 1963 are given in table 6 and presented in conjunction with

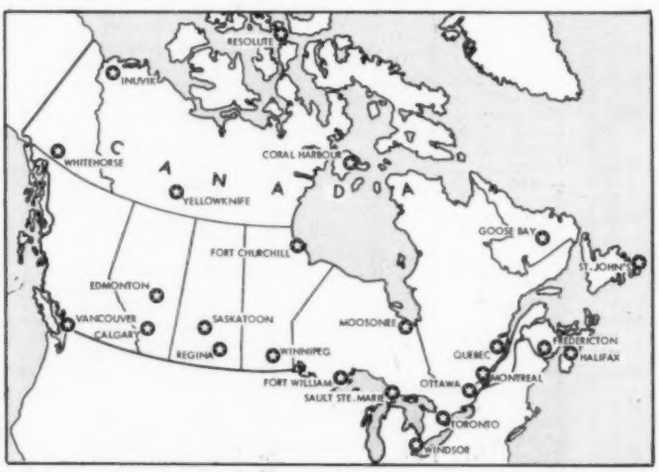

FIGURE 4.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS, DECEMBER 1963

TABLE 6.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, CANADA, DECEMBER 1963

[Average concentrations in pc/m³]

Station	Number of Samples	Maximum	Minimum	Average
Calgary	29	2.6	0.0	1.1
Coral Harbour	31	1.4	0.2	0.8
Edmonton	30	1.4	0.4	0.9
Ft. Churchill	31	1.7	0.1	0.8
Ft. William	30	1.7	0.4	1.1
Fredericton	31	1.4	0.3	0.8
Goose Bay	30	1.2	0.1	0.7
Halifax	28	2.1	0.4	1.0
Inuvik	31	2.4	0.5	1.0
Montreal	29	2.3	0.3	0.9
Moosonee	30	1.4	0.1	0.9
Ottawa	30	1.3	0.4	0.8
Quebec	29	1.7	0.1	0.9
Regina	31	2.3	0.3	0.9
Resolute	31	1.9	0.1	0.8
St. John's, Nfld.	31	2.1	0.1	0.7
Saskatoon	30	2.1	0.4	0.9
Sault Ste. Marie	31	1.4	0.3	0.9
Toronto	31	0.5	0.1	0.3
Vancouver	31	1.9	0.2	0.7
Whitehorse	31	1.5	9.2	0.6
Windsor	30	1.8	0.4	0.9
Winnipeg	31	1.8	0.5	0.9
Yellowknife	30	1.3	0.3	0.8
Network summary	727	2.6	0.0	0.8

TABLE 7.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, CANADA, DECEMBER 1963

Station	Total beta activity	
	pc/liter	nc/m²
Calgary	588	12.4
Coral Harbour	1487	12.1
Edmonton	739	7.5
Ft. Churchill	427	7.5
Ft. William	301	8.0
Fredericton	146	9.8
Goose Bay	102	10.2
Halifax	250	43.7
Inuvik	511	6.1
Montreal	353	10.3
Moosonee	2894	49.9
Ottawa	195	5.8
Quebec	1111	46.8
Regina	501	5.3
Resolute	398	17.2
St. John's, Nfld.	518	40.9
Saskatoon	415	4.1
Sault Ste. Marie	364	33.0
Toronto	537	14.7
Vancouver	381	91.8
Whitehorse	468	7.3
Windsor	364	13.9
Winnipeg	506	13.6
Yellowknife	353	2.9
Average	580	19.8

U. S. and Mexican data by an isogram map (figure 6).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}-Y^{90} source. Gross beta activities for December samples are given in table 7. Radionuclide analyses appear quarterly.

4. Mexican Air Monitoring Program, December 1963

National Commission of Nuclear Energy, Mexico

The Radiation Surveillance Network of Mexico was established by the Comision Nacional de Energia Nuclear (CNEN) through its Radiological Protection Program (RPP) in 1961. The network consists of 17 stations (see figure 5), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada. Staff members of the RPP operate the station at Mexico City while the other four stations are manned by members of the Centro de Prevision del Golfo de Mexico, the Chemistry Department of the University of Mérida, the Instituto de Zonas Deserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

FIGURE 5.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

TABLE 8.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, DECEMBER 1963

[Concentrations in pc/m³]

Station	Number of Samples	Maximum	Minimum	Average
Acapulco	10	0.7	0.1	0.2
Ciudad Juárez	18	2.8	0.1	1.0
Chihuahua	18	2.2	0.4	1.2
Ensenada	9	2.9	0.6	1.4
Guadalahara	5	2.1	0.2	0.9
Guaymas [a]				
La Paz	11	2.4	0.6	1.4
Matamoros	2	2.2	0.8	
Mazatlán [a]				
Mérida	7	2.3	0.2	1.0
Mexico City	20	0.9	0.1	0.2
Nuevo Laredo [a]				
San Luis Potosí	18	1.4	<0.1	0.3
Tampico	8	1.2	0.1	0.6
Torreón	8	1.9	0.2	1.1
Tuxtla Gutiérrez [a]				
Veracruz	6	0.9	<0.1	0.1

[a] Equipment out of order.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency glass fiber filter, 6 x 8 inch, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios Sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

The maximum, minimum and average fission product beta concentrations in surface air during December 1963 are presented in table 8. The data are also represented in the beta activity isogram map of North America, figure 6.

5. Pan American Air Sampling Program, December 1963

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by three countries in South America under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas to develop their own radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The three air sampling stations included in the program are operated by the technical staff of the Ministry of Health in each country. The station in Santiago, Chile, is operated by the Occupational Health Service; in Lima, Peru, by the Institute of Occupational Health; and in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations. The Caracas station began operation in November 1962 and the other two stations were started the following month.

The December 1963 air monitoring results from the three participating countries are given in table 9. The Caracas station is shown on the gross beta concentration isogram map (figure 6). The December average at this station, adjusted by the RSN intercalibration factor,[4] is less than 0.28 pc/m³, which is considerably below the lowest isogram used on the map (1 pc/m³).

TABLE 9.—GROSS BETA ACTIVITY IN AIR, DECEMBER 1963

[Concentrations in pc/m³]

Sampling stations	Number of Samples	Maximum	Minimum	Average [a]
Caracas, Venezuela	23	0.49	<0.10	0.22
Lima, Peru	14	0.18	<0.10	<0.13
Santiago, Chile	13	0.24	<0.10	<0.13

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

6. Gross Beta Activity in Air, North America, December 1963

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America.[5] The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*8*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, National Air Sampling Network, the new 80th Meridian Network, and the Mexican Network (*9*). The new intercalibration factors include some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963. The intercalibration factors are, therefore, not the same as were previously used.

Figure 6 shows the December 1963 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network and Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN data and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

[4] The RSN factor is 1.28 (see below).

[5] The January through October 1963 Isogram Maps were published in the May 1963 through February 1964 issues of *Radiological Health Data.*

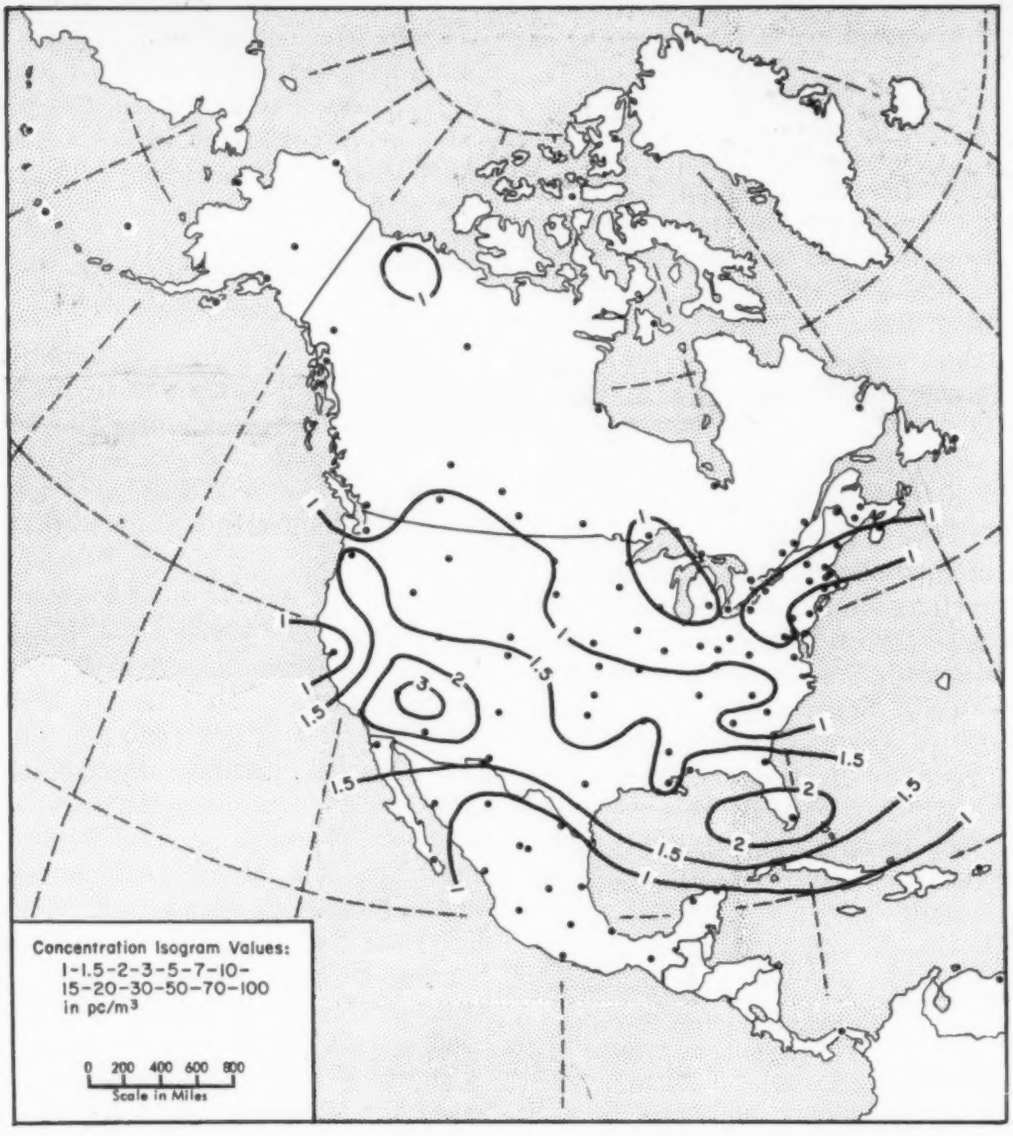

FIGURE 6.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR THROUGHOUT NORTH AMERICA, DECEMBER 1963

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STRONTIUM-90 DEPOSITION ON THE EARTH'S SURFACE—1962[1]

William R. Collins Jr.[2]

Quarterly strontium-90 deposition figures by latitude bands, based on the world-wide pot and resin column collections made by the Health and Safety Laboratory (HASL) during 1958 through 1961, have been reported previously (*1*, *2*). Similar data for 1962 are given below with a review of the previous data for comparison. The locations of the sampling sites are shown in figure 1.

In previous years strontium-89 and tungsten-185 measurements have been used to estimate relative contributions of different sources to total fallout radioactivity. During 1962, strontium-89 measurements were used as a means of distinguishing between old debris and that from nuclear test series conducted during 1961 and 1962.

Average monthly strontium-90 deposition figures for 1962 for each ten degrees of latitude from 80° north to 50° south are presented in table 1. Yearly sums of these values for each of the latitude bands are listed under the monthly values in table 1 and are plotted in figure 2. In this calculation, as discussed previously (*2*), it is assumed that the mean value for the selected sites is representative of the entire latitude band; the effects of rainfall differences are not considered. Estimates of total quarterly hemispheric depositions of strontium-90 for 1958-1962 are listed in table 2 and are plotted in figure 3.

From the data it was estimated that 1.49 megacuries of strontium-90 were deposited on the earth's surface during 1962. If it is assumed that the fallout patterns illustrated in figure 3 for 1960 and the first 3 quarters of 1961 represent a trend toward stabilization of deposition rates from premoratorium test series, it is unlikely that the 1962 depositions of strontium-90 in the Northern and Southern Hemispheres would have exceeded 0.22 and 0.12 megacuries, respectively. The actual values are 1.26 and 0.23 megacuries. Thus, at

[1] Summarized from Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL-140*: 240-247, Washington, D. C. 20430 (October 1, 1963).

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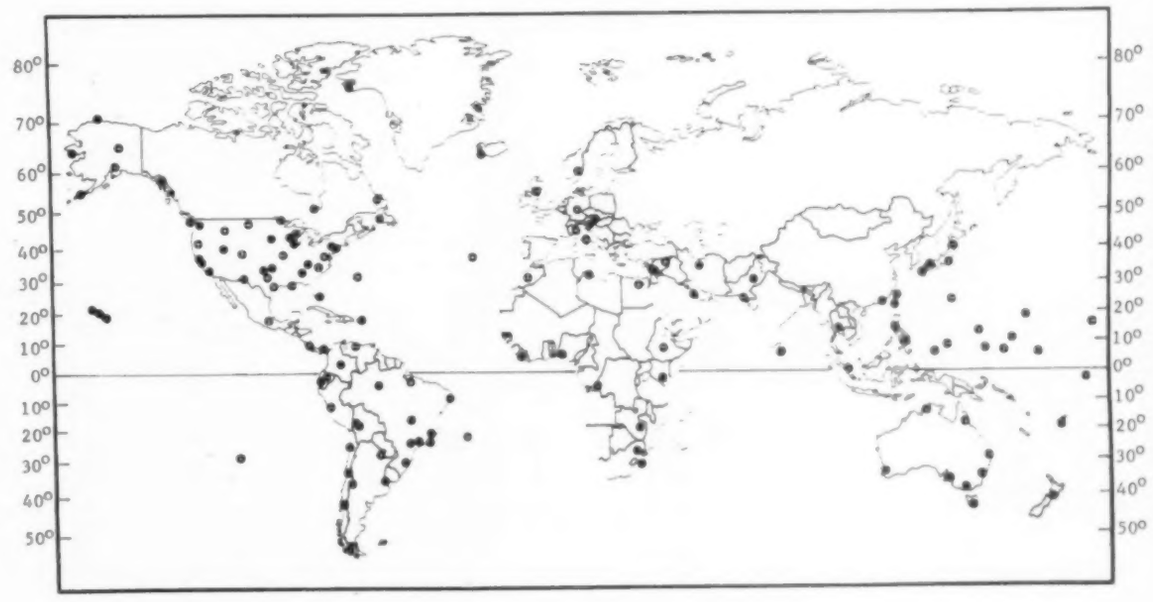

FIGURE 1.—HASL FALLOUT SAMPLING LOCATIONS

TABLE 1.—1962 AVERAGE STRONTIUM-90 FALLOUT RATE BY 10° BANDS OF LATITUDE

Latitude bands	80–70°N	70–60°N	60–50°N	50–40°N	40–30°N	30–20°N	20–10°N	10–0°N	0–10°S	10–20°S	20–30°S	30–40°S	40–50°S
No. of sites	2	4	6	20	26	12	12	12	10	7	10	8	2
1962 Monthly deposition (mc/mi²)													
January	0.01	0.78	0.89	0.86	1.66	1.68	0.42	0.38	0.57	0.23	0.29	0.26	0.90
February	0.01	0.88	0.75	1.52	2.29	1.61	0.51	1.05	0.28	0.16	0.22	0.23	0.10
March	0.01	0.74	1.06	1.74	2.38	2.63	0.56	1.12	0.22	0.09	0.18	0.21	0.20
April	0.16	1.17	0.80	2.65	2.20	1.75	1.00	0.59	1.16	0.04	0.09	0.07	0.11
May	1.06	0.80	2.68	4.48	1.89	2.40	0.78	0.73	0.52	0.07	0.16	0.11	0.14
June	0.60	1.78	2.55	2.80	1.62	1.13	0.78	0.70	0.78	0.18	0.09	0.18	0.21
July	0.31	1.21	1.65	1.95	0.91	0.79	0.72	0.74	0.14	0.13	0.25	0.17	0.18
August	0.64	1.34	1.67	1.98	0.45	0.58	0.46	0.67	0.25	0.09	0.18	0.22	0.16
September	0.80	1.38	1.96	1.06	0.53	0.98	0.27	0.23	0.13	0.22	0.27	0.20	0.16
October	0.12	0.74	1.04	1.10	0.81	0.77	0.20	0.21	0.15	0.13	0.43	0.20	0.66
November	0.09	0.79	1.01	1.35	1.33	0.61	0.20	0.34	0.12	0.28	0.48	0.26	0.22
December	0.04	0.84	0.97	0.84	1.23	0.83	0.24	0.27	0.26	0.31	0.55	0.26	0.21
1962 Total deposition (mc/mi²)	3.85	12.45	17.03	22.23	17.30	15.76	6.14	7.03	4.58	1.93	3.19	2.37	3.25
(nc/m²)	1.49	4.81	6.57	8.62	6.68	6.08	2.37	2.71	1.77	0.74	1.23	0.91	1.25
Total Sr^{90} deposition during 1962 (Megacuries)	0.017	0.090	0.168	0.271	0.244	0.246	0.102	0.120	0.078	0.032	0.050	0.033	0.040

least 83 percent of the northern hemispheric deposition, 48 percent of the southern hemispheric deposition and 77 percent of the total global deposition during 1962 originated from the 1961 and 1962 tests.

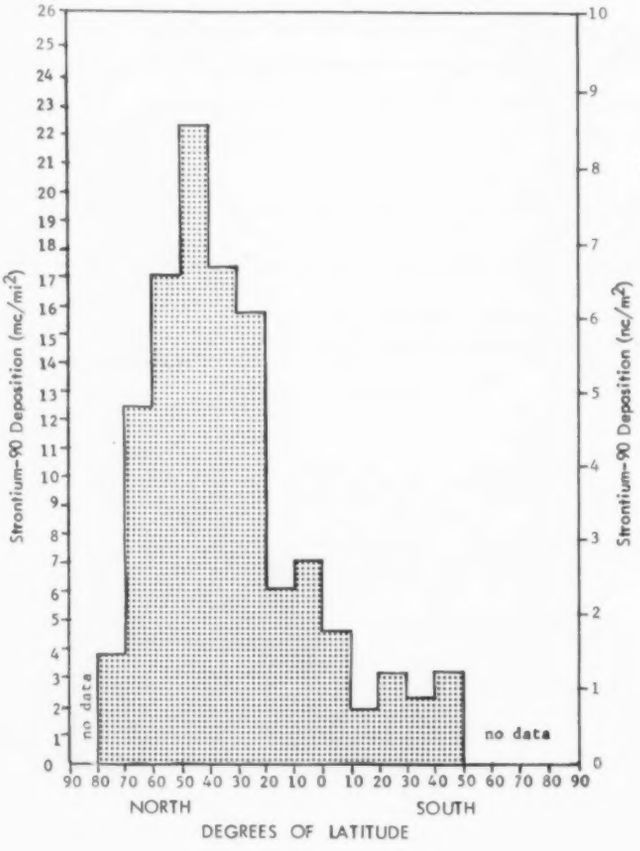
Strontium-90 Deposition (mc/mi²)
Strontium-90 Deposition (nc/m²)
no data
no data
90 80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80 90
NORTH
SOUTH
DEGREES OF LATITUDE

FIGURE 2.—TOTAL STRONTIUM-90 DEPOSITION DURING 1962 *VS* LATITUDE BAND

Average Sr^{89}/Sr^{90} ratios obtained for each ten degrees of latitude covered by the sampling program are listed in table 3, and average ratios for the Northern Hemisphere (10°-80°N), the equatorial region (10°N-10°S), and the Southern Hemisphere (10°-50°S) are plotted by sampling month in figure 4. The lengths of the post-moratorium test series relative to the 30 day sampling period and the 50.5-day half-life of strontium-89 limit the usefulness of these measurements in distinguishing between sources of debris. However, the isotope ratios do indicate that debris from the 1961 Soviet tests continued to arrive in the Northern Hemisphere during 1962 with no significant penetrations to latitudes below 10°S. Debris from U. S. equatorial tests conducted during the late spring and early summer of 1962 pre-

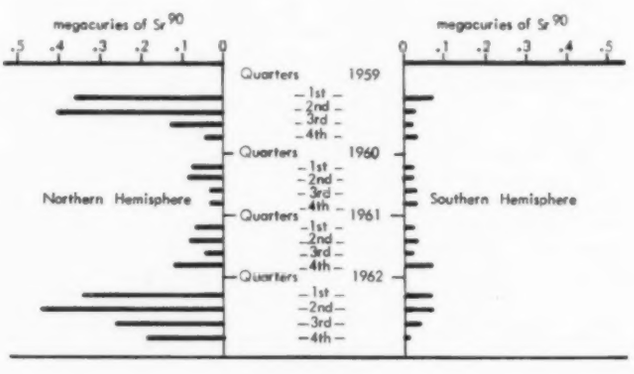

FIGURE 3.—QUARTERLY DEPOSITION OF STRONTIUM-90, 1959-1962

TABLE 2.—ESTIMATES OF TOTAL STRONTIUM-90 DEPOSITION BY HEMISPHERE AND QUARTER

[Megacuries]

Period	Northern Hemisphere	Southern Hemisphere	Northern and Southern Hemispheres
1958			
First quarter			0.14
Second quarter			0.24
Third quarter			0.18
Fourth quarter			0.21
Total			0.77
1959			
First quarter	0.36	0.066	0.43
Second quarter	0.41	0.025	0.43
Third quarter	0.12	0.025	0.14
Fourth quarter	0.04	0.033	0.08
Total	0.93	0.149	1.08
1960			
First quarter	0.079	0.027	0.106
Second quarter	0.086	0.022	0.108
Third quarter	0.036	0.022	0.058
Fourth quarter	0.029	0.035	0.064
Total	0.230	0.106	0.336
1961			
First quarter	0.064	0.028	0.092
Second quarter	0.082	0.030	0.112
Third quarter	0.045	0.027	0.072
Fourth quarter	0.124	0.062	0.186
Total	0.315	0.147	0.462
1962			
First quarter	0.344	0.062	0.406
Second quarter	0.455	0.063	0.518
Third quarter	0.265	0.041	0.306
Fourth quarter	0.195	0.067	0.262
Total	1.259	0.233	1.492

dominated in fallout below 10°N latitude from April through August of 1963 and in fallout below 10°S latitude through the end of the year. Debris from the fall 1962 U.S.S.R. and U. S. tests appeared in mixed fallout from August through the end of the year, primarily at latitudes north of 10°S.

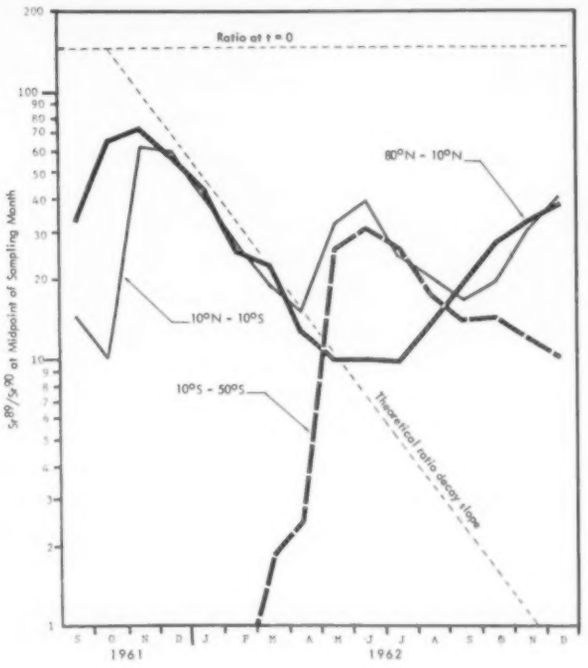

FIGURE 4.—RATIO OF STRONTIUM-89 TO STRONTIUM-90, BY SAMPLING MONTH FOR DIFFERENT GLOBAL REGIONS

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TABLE 3.—RATIOS OF STRONTIUM-89 TO STRONTIUM-90 AT MIDPOINT OF COLLECTION PERIOD BY 10° LATITUDE BANDS—1962

Period	80–70°N	70–60°N	60–50°N	50–40°N	40–30°N	30–20°N	20–10°N	10–0°N	0–10°S	10–20°S	20–30°S	30–40°S	40–50°S
January	34	49	45	43	42	44	44	48	36	1	<1	<1	<1
February	<1	30	26	33	28	29	29	25	26	2	1	<1	<1
March	20	43	23	18	20	18	28	18	19	3	3	1	<1
April	8	15	13	12	13	13	14	14	16	2	5	3	<1
May	8	10	8	9	11	10	14	18	46	20	39	36	10
June	2	8	10	8	10	13	19	37	41	35	55	22	11
July	* —	10	8	10	13	15	12	25	24	18	28	32	19
August	—	25	10	12	13	15	17	18	22	13	21	18	16
September	20	24	21	19	16	19	15	17	16	12	17	12	15
October	17	28	32	29	28	28	29	24	15	9	14	11	24
November	—	42	36	40	42	32	40	42	24	15	11	7	15
December	25	47	41	37	43	38	32	38	42	12	8	13	7

* No data received.

FISSION PRODUCT GAMMA ACTIVITY IN AIR— 80TH MERIDIAN NETWORK, NOVEMBER 1963

Health and Safety Laboratory, Atomic Energy Commission

Total gamma activity measurements for weekly ground-level air filter samples taken at 80th Meridian stations (see figure 1) during November 1963 are listed in table 1, together with monthly average concentrations and the ratios of the gamma photons in excess of 1 Mev to the total gamma activity. The November average total gamma concentrations are plotted in figure 2, as an activity-latitude profile and compared with the third quarter average profile. Details of sampling procedures and analytical methodology have previously been described (*1*, *2*).

The November results in general show slight decreases in ground level air activity concentrations in both the Northern and the Southern Hemisphere with respect to results obtained for October 1963. Levels in the Northern Hemisphere remained about ten times higher than

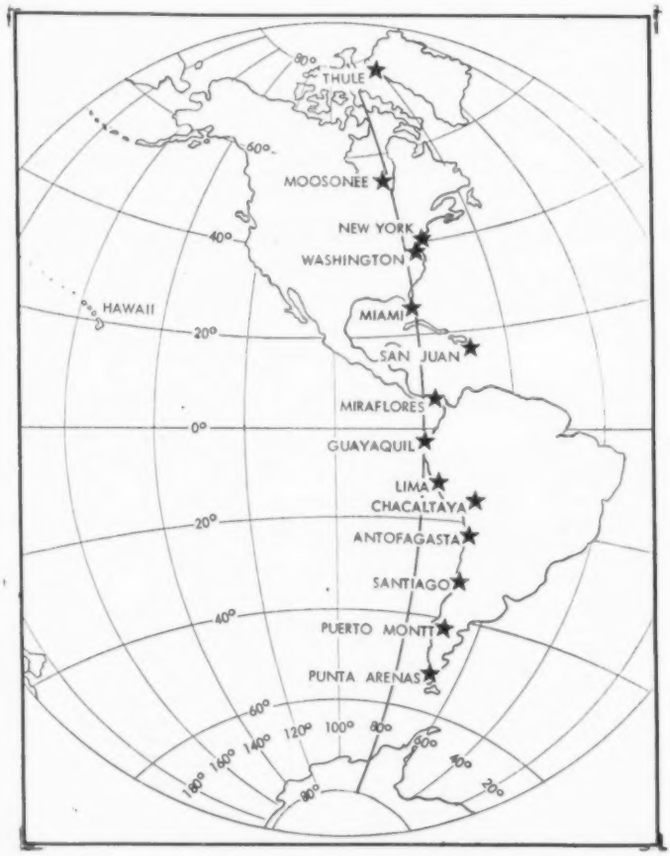

FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS

TABLE 1.—ACTIVITY OF SURFACE AIR, 80TH MERIDIAN NETWORK, NOVEMBER 1963

Sampling station	Sampling period (dates—noon to noon)	Gamma activity (photons/min/m³)		Gamma ratio $\left(\frac{\gamma > 1 \text{ Mev}}{\text{total } \gamma}\right)$
		Filter	Average for month	
Thule, Greenland	11/ 1–8	1.03		0.043
	11/ 8–15	0.472		0.047
	11/15–22	0.690		0.045
	11/22–12/1	1.045	0.808	0.043
Moosonee, Canada	11/1–8	0.368		0.045
	11/ 8–15	0.317		0.051
	11/15–22	0.482		0.053
	11/22–12/1	0.475	0.411	0.051
New York, N. Y.	11/ 1–8	0.966		0.052
	11/ 8–15	0.310		0.054
	11/15–22	0.895		0.053
	11/22–12/1	0.775	0.737	0.051
Washington, D. C.	11/ 1–8	0.714		0.051
	11/ 8–15	0.503		0.053
	11/15–22	1.30		0.052
	11/22–12/1	1.16	0.919	0.051
Miami, Florida	11/ 1–8	1.69		0.054
	11/ 8–15	0.870		0.052
	11/15–22	1.66		0.053
	11/22–12/1	0.915	1.28	0.044
Mauna Loa, Hawaii*	11/ 1–8	0.353		0.052
	11/ 8–15	0.538		0.052
	11/15–22	0.241		0.046
	11/22–12/1	0.377	0.377	0.051
San Juan, P. R.	11/ 1–8	0.423		0.050
	11/ 8–15	0.360		0.051
	11/15–22	0.386		0.042
	11/22–12/1	0.557	0.432	0.041
Miraflores, Canal Zone	11/ 1–8	0.0209		0.071
	11/ 8–15	0.0971		0.052
	11/15–22	0.203		0.056
	11/22–12/1	0.437	0.190	0.053
Guayaquil, Ecuador	11/ 1–8	0.0536		0.054
	11/ 8–15	0.0555		0.046
	11/15–22	0.0661		0.036
	11/22–12/1	0.0409	0.0540	0.044
Lima, Peru	11/ 1–8	0.133		0.064
	11/ 8–15	0.176		0.053
	11/15–22	0.162		0.030
	11/22–12/1	0.203	0.169	0.079
Chacaltaya, Bolivia	11/ 1–8	0.0515		0.037
	11/ 8–15	0.130		0.048
	11/15–22	0.0762		0.040
	11/22–12/1	0.0420	0.0749	0.046
Antofagasta, Chile	11/ 1–8	0.0692		0.066
	11/ 8–15	0.0853		0.065
	11/15–22	0.0754		0.049
	11/22–12/1	0.0754	0.0763	0.054
Santiago, Chile	11/ 1–8	0.0747		0.054
	11/ 8–15	0.0704		0.047
	11/15–22	0.0710		0.048
	11/22–12/1	0.0690	0.0713	0.046
Puerto Montt, Chile	11/ 1–8	0.0410		0.020
	11/ 8–15	0.0521		0.036
	11/15–22	0.0504		0.029
	11/22–12/1	0.0605	0.0510	0.050
Punta Arenas, Chile	11/ 1–8	0.0155		0.078
	11/ 8–15	0.0168		0.062
	11/15–22	0.0147		0.048
	11/22–12/1	0.0226	0.0174	0.015

* Mauna Loa data have been included for comparison with Chacaltaya, Bolivia. Both are high elevation stations (3400 and 5200 meters, respectively) and about equally distant north and south of the equator.

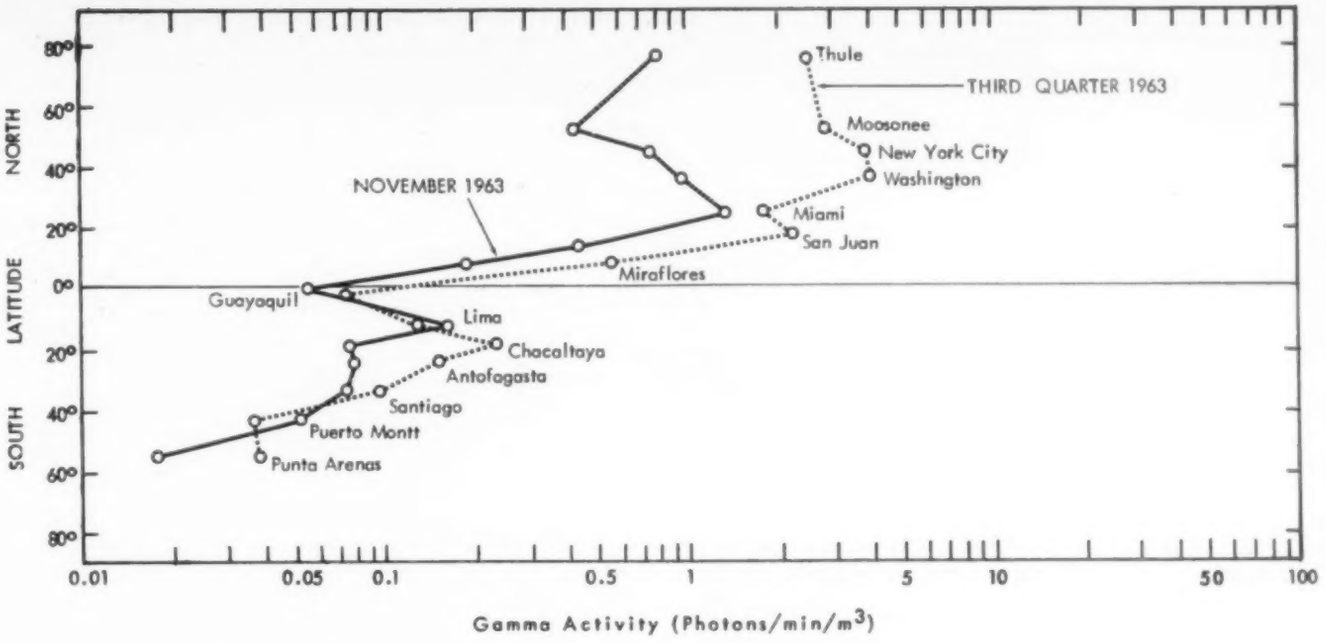

FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, THIRD QUARTER, OCTOBER AND NOVEMBER 1963

those in the Southern Hemisphere with averages of 0.646 photons per minute per cubic meter (γ/min/m^3) and 0.0733 γ/min/m^3, respectively.

As in previous months the ratios of photons in excess of 1 Mev to total photons indicate the presence of larger concentrations of high-energy gamma emitters than would be expected in old fission product mixtures (*1*). Since June 1963, radiochemical and gamma spectrometric analyses have been in process to determine to what extent enrichment in high-energy activation products such as Y^{88} and Sb^{124} and fission products such as Ce^{144} and Ru^{106} is responsible for these discrepancies.

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Section II.—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, December 1963

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after collection; publication in *RHD* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected

twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Analytical Errors

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy.[1] After gamma scanning, samples from two consecutive weeks are composited and analyzed radiochemically for strontium-89 and strontium-90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation is dependent upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. The $\pm 2\sigma$ range about the measured concentration corresponds to a 95 percent certainty that the true concentration is within this range. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations determined from the gamma spectrum.

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error[a] (pc/liter)	Estimated concentration (pc/liter)	Error[a] (percent of concentration)
Iodine-131	0 to 100	± 10	100 or greater	± 10%
Barium-140	0 to 100	± 10	100 or greater	± 10%
Cesium-137	0 to 100	± 10	100 or greater	± 10%
Strontium-89	0 to 50	± 5	50 or greater	± 10%
Strontium-90	0 to 20	± 2	20 or greater	± 10%

[a] Two standard deviations.

Data Presentation

Table 2 presents summaries of the analyses for December 1963 (December 1-28, 1963). Although not shown in table 2, the iodine-131 and barium-140 monthly average concentrations in milk were less than 10 pc/liter. When a radionuclide is reported by laboratory as being below the minimum detectable concentration, one-half the minimum detectable value is used as the best approximation in calculating the monthly average. Beginning with October 1963 data, however, zero has been used as the best approximation to a nondetectable concentration of iodine-131 or barium-140. A similar procedure is used for the network average.

Figures 1, 2, and 3 are isogram maps showing the estimated strontium-89, strontium-90, and cesium-137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations versus radionuclide concentrations in milk, table 3 has been prepared using monthly averages shown in table 2.

Continuing the practice followed in previous issues of *RHD*, the average monthly strontium-90 concentrations in pasteurized milk from 16 selected cities in the sampling program are presented in figure 4. Each graph shows the strontium-90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year.

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, DECEMBER 1963[a]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr^{90} graph in *RHD* (1964)
		Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	
Ala:	Montgomery	1.22	1.24	1.5	1.5	5	<5	21	23	85	95	February
Alaska:	Palmer	1.20	1.14	1.6	1.6	15	10	31	27	180	160	March
Ariz:	Phoenix	1.16	1.15	1.7	1.6	<5	<5	3	3	30	25	January
Ark:	Little Rock	1.20	1.20	1.5	1.5	10	5	40	42	130	140	March
Calif:	Sacramento	1.22	1.24	1.6	1.6	<5	<5	8	8	60	60	April
	San Francisco	1.22	1.19	1.6	1.5	5	5	9	11	70	75	February
C. Z:	Cristobal	1.13	1.13	1.5	1.5	<5	<5	5	6	40	45	March
Colo:	Denver	1.19	1.20	1.6	1.6	15	10	17	16	85	85	April
Conn:	Hartford	1.19	1.16	1.6	1.6	10	<5	25	26	170	185	April
Del:	Wilmington	1.21	1.22	1.7	1.7	5	<5	23	22	130	145	January
D. C:	Washington	1.17	1.18	1.5	1.4	10	<5	17	18	80	90	February
Fla:	Tampa	1.22	1.25	1.4	1.4	5	<5	16	16	250	205	January
Ga:	Atlanta	1.19	1.19	1.5	1.4	10	5	29	28	120	120	February
Hawaii:	Honolulu	1.15	1.19	1.7	1.6	10	<5	11	10	85	80	March
Idaho:	Idaho Falls	1.19	1.21	1.6	1.6	15	10	26	32	170	200	January
Ill:	Chicago	1.18	1.17	1.7	1.6	10	<5	20	21	110	130	February
Ind:	Indianapolis	1.25	1.28	1.6	1.6	10	<5	22	23	100	120	April
Iowa:	Des Moines	1.18	1.17	1.5	1.5	15	10	25	26	100	115	January
Kans:	Wichita	1.16	1.20	1.6	1.6	10	5	18	21	65	60	March
Ky:	Louisville	1.16	1.17	1.5	1.5	15	10	30	32	100	120	January
La:	New Orleans	1.24	1.22	1.5	1.4	15	5	44	47	135	125	March
Maine:	Portland	1.22	1.22	1.6	1.6	10	<5	35	34	235	230	January
Md:	Baltimore	1.14	1.17	1.4	1.4	10	5	20	21	105	130	January
Mass:	Boston	1.22	1.22	1.6	1.6	15	<5	36	35	250	260	February
Mich:	Detroit	1.20	1.18	1.6	1.6	5	<5	20	20	120	130	April
	Grand Rapids	1.23	1.22	1.6	1.6	5	<5	22	20	130	140	January
Minn:	Minneapolis	1.18	1.21	1.6	1.6	25	10	33	37	155	170	February
Miss:	Jackson	1.25	1.26	1.4	1.4	15	10	36	38	105	120	April
Mo:	Kansas City	1.17	1.16	1.5	1.5	15	10	29	27	85	95	April
	St. Louis	1.20	1.19	1.6	1.6	15	10	21	21	85	100	March
Mont:	Helena	1.20	1.21	1.6	1.6	10	5	29	28	195	210	March
Nebr:	Omaha	1.20	1.23	1.6	1.6	25	15	25	23	95	95	January
Nev:	Las Vegas	1.14	1.18	1.7	1.6	<5	<5	10	12	80	80	February
N. H:	Manchester	1.24	1.28	1.6	1.6	10	5	37	34	275	280	January
N. J:	Trenton	1.20	1.19	1.6	1.6	10	<5	19	19	120	130	April
N. Mex:	Albuquerque	1.16	1.17	1.6	1.6	<5	<5	11	12	50	50	March
N.Y:	Buffalo	1.18	1.16	1.7	1.6	10	<5	23	24	145	160	April
	New York	1.20	1.19	1.7	1.6	15	<5	30	28	175	195	February
	Syracuse	1.19	1.18	1.7	1.7	10	<5	22	22	150	170	March
N. C:	Charlotte	1.19	1.22	1.5	1.5	15	10	30	30	105	110	March
N. Dak:	Minot	1.18	1.20	1.6	1.6	40	20	55	60	145	165	January
Ohio:	Cincinnati	1.23	1.22	1.6	1.6	10	<5	23	24	90	110	April
	Cleveland	1.22	1.22	1.7	1.6	5	<5	22	23	105	120	March
Okla:	Oklahoma City	1.17	1.22	1.5	1.4	5	5	21	24	70	80	February
Ore:	Portland	1.21	1.20	1.6	1.6	20	10	30	26	180	155	April
Pa:	Philadelphia	1.22	1.22	1.6	1.6	5	<5	21	21	120	140	March
	Pittsburgh	1.27	1.35	1.6	1.6	10	<5	29	32	145	165	March
P. R:	San Juan	1.16	1.16	1.5	1.5	5	<5	12	12	65	70	March
R. I:	Providence	1.21	1.20	1.6	1.6	5	<5	27	27	175	190	January
S. C:	Charleston	1.21	1.20	1.5	1.4	10	5	27	28	120	115	April
S. Dak:	Rapid City	1.20	1.22	1.7	1.8	25	10	42	48	170	185	February
Tenn:	Chattanooga	1.23	1.22	1.5	1.4	15	10	35	38	120	130	February
	Memphis	1.22	1.23	1.5	1.5	10	5	28	29	75	80	January
Tex:	Austin	1.18	1.17	1.5	1.5	<5	<5	8	9	40	40	February
	Dallas	1.20	1.21	1.5	1.5	5	<5	19	20	75	90	April
Utah:	Salt Lake City	1.19	1.19	1.6	1.6	15	5	26	26	170	190	March
Vt.	Burlington	1.21	1.21	1.6	1.7	10	<5	28	28	200	220	April
Va:	Norfolk	1.17	1.17	1.5	1.5	10	5	21	20	90	95	April
Wash:	Seattle	1.21	1.20	1.6	1.6	15	5	24	17	155	115	February
	Spokane	1.21	1.17	1.7	1.6	20	5	31	30	160	165	April
W. Va:	Charleston	1.17	1.19	1.4	1.5	15	10	26	27	85	100	February
Wis:	Milwaukee	1.28	1.28	1.8	1.7	<5	<5	19	20	135	155	January
Wyo:	Laramie	1.18	1.19	1.6	1.5	15	10	20	17	115	110	January
Network average		1.20	1.20	1.6	1.6	11	5	24.2	24.6	123	130	

[a] The monthly average iodine-131 and barium-140 concentration at each station was <10 pc/liter.

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, DECEMBER 1963

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
<5–5	46	<1–4	1	<10	63	<5–45	3	<10	63
10	15	5–9	3			50–95	16		
15	1	10–14	5			100–145	23		
20	1	15–19	6			150–195	14		
		20–24	19			200–245	5		
		25–29	14			250–295	2		
		30–34	7						
		35–39	4						
		40–60	4						
Total	63	Total	63	Total	63	Total	63	Total	63

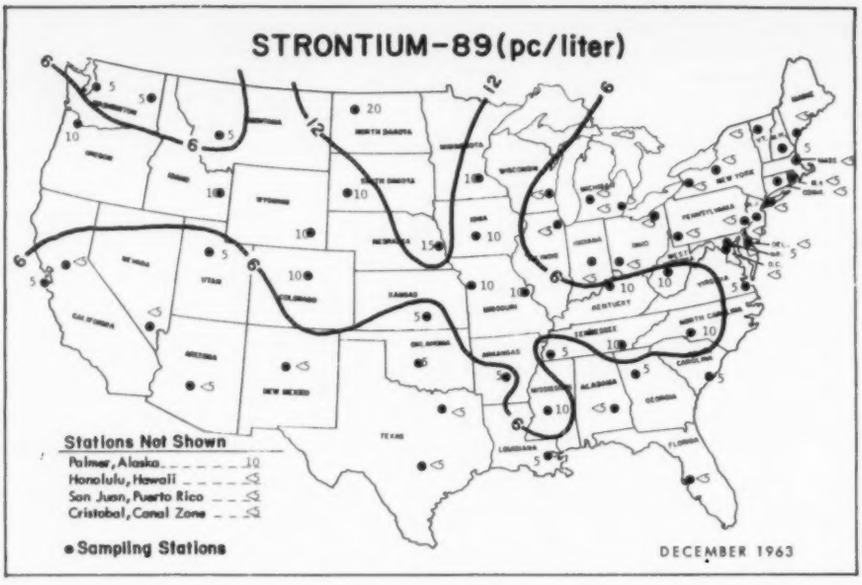

FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK, DECEMBER, 1963

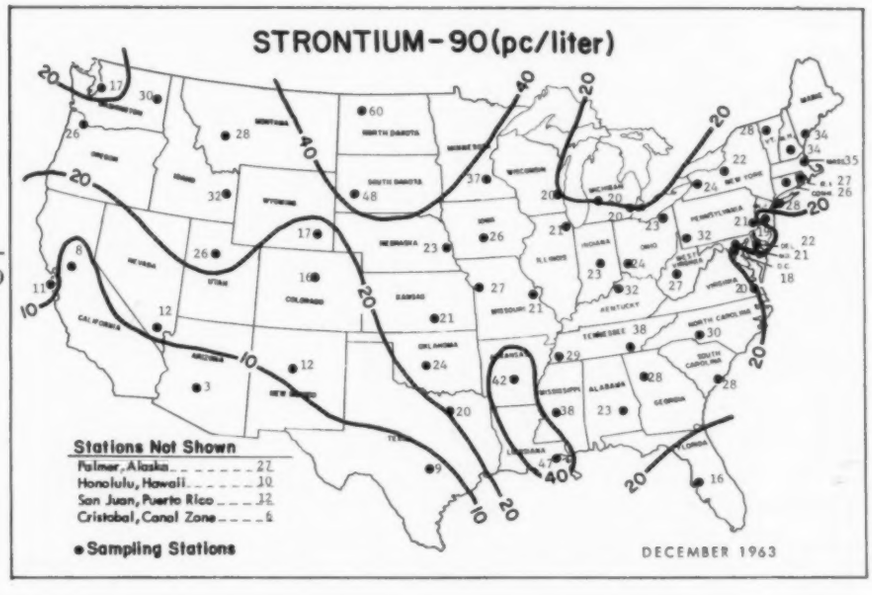

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, DECEMBER, 1963

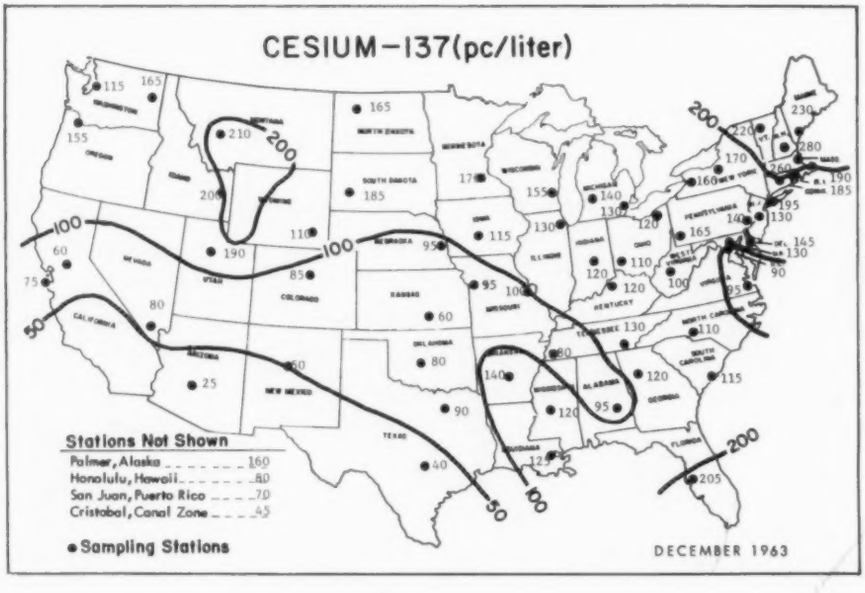

FIGURE 3.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, DECEMBER 1963

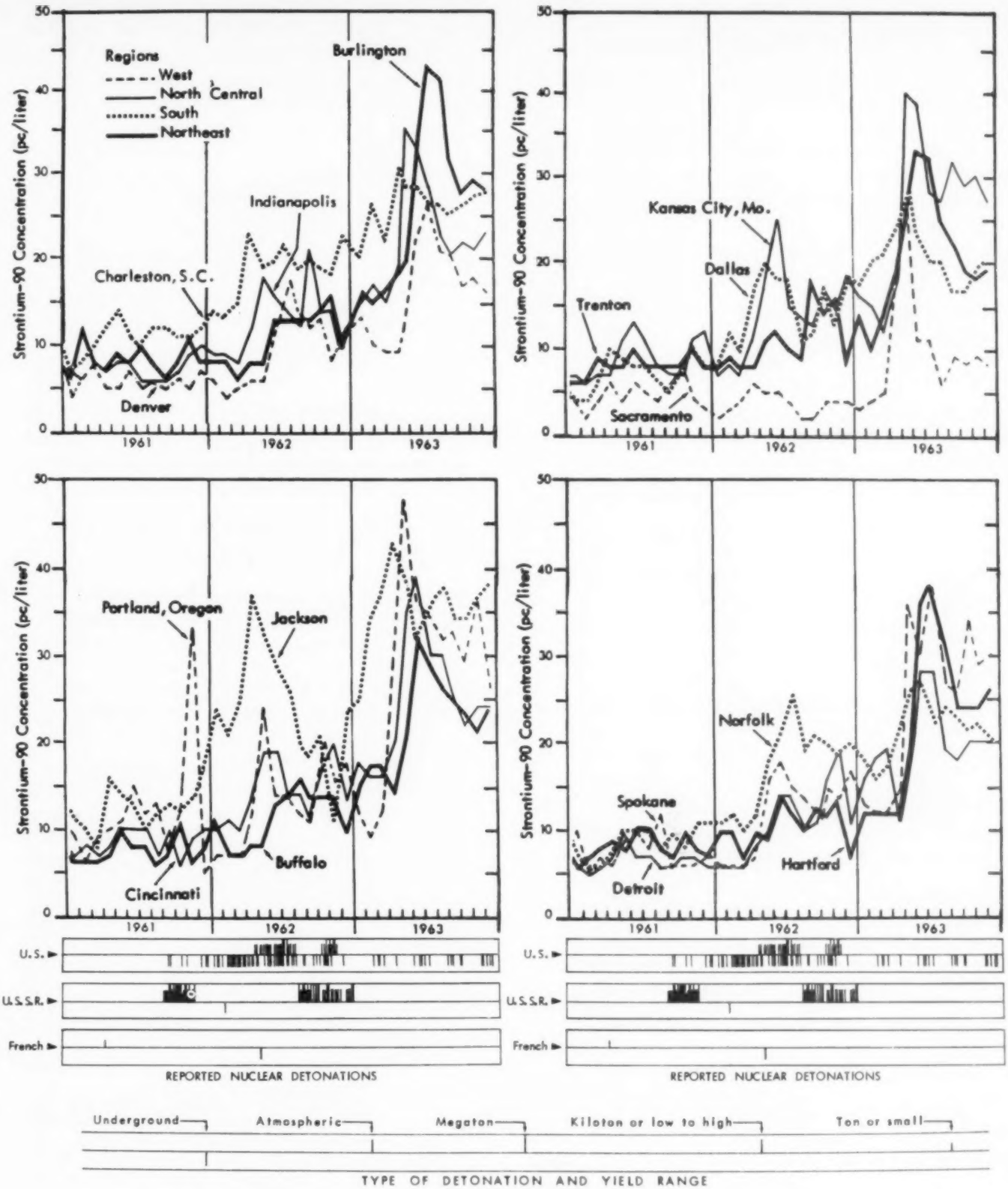

FIGURE 4.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, 1961-DECEMBER 1963

2. Indiana Milk Network, December 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 5).

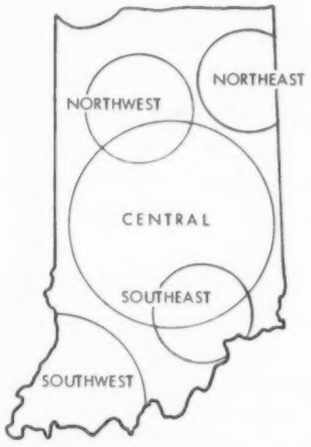

FIGURE 5.—INDIANA MILK SAMPLING LOCATIONS

The milk samples are routinely analyzed for iodine-131, cesium-137, barium-140, strontium-89 and strontium-90. Until August 1963, analyses for the gamma emitters iodine-131, cesium-137 and barium-140 were conducted on a weekly basis, except when iodine-131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentrations of the short-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium-89 and strontium-90 analyses are performed monthly for each station.

An ion exchange analytical procedure (*2*) is used for strontium-89 and strontium-90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine-131 cesium-137, and barium-140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 4. The State average is an arithmetic average of the station values.

TABLE 4.—RADIONUCLIDES IN INDIANA MILK, DECEMBER 1963[a]

[Concentrations in pc/liter]

Sampling location	Sr^{89}	Sr^{90}	Cs^{137}	Ba^{140}
Northeast	10	13	120	0
Southeast	5	17	125	10
Central	0	14	110	0
Southwest	0	13	120	0
Northwest	5	14	130	0
State average	5	14	120	0

[a] The monthly average iodine-131 concentration at each station was zero.

3. Canadian Milk Network,[2] December 1963

Radiation Protection Division
Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 6) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine-131, strontium-89, cesium-137 and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical

[2] Data from *Radiation Protection Programs, Vol. 1, No. 1*:27-30, Radiation Protection Division, Canadian Department of National Health and Welfare (January 1964).

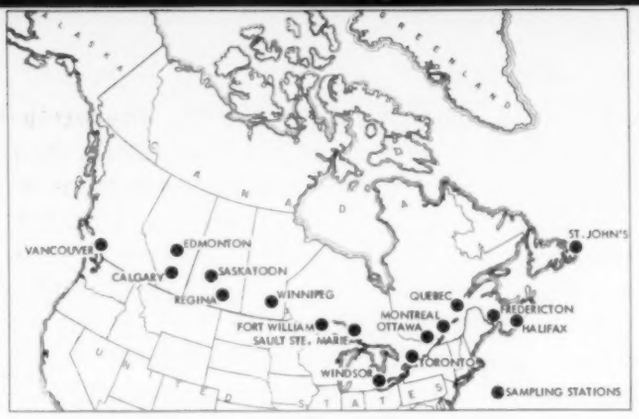

FIGURE 6.—CANADIAN MILK SAMPLING STATIONS

laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, strontium-89, cesium-137, and stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine-131 (*3*). Carrier iodine is added and the milk is then evaporated in the presence of sodium hydroxide and ashed. The iodide ion is oxidized to free iodine and extracted with carbon tetrachloride, back-extracted in sulfite solution, and precipitated as silver iodide. The precipitate is counted in a low background beta counter and the iodine-131 determined by comparison with standard preparations.

For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet, and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450°C, dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium-89 and strontium-90 are determined by counting in a low background beta counter. Strontium-90 is determined separately by extracting and counting the yttrium-90 daughter nuclide while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium-137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium-40 and cesium-137 content of the milk by comparison of the spectrum with standard preparations. The stable potassium content is estimated from the potassium-40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotpe in the milk because it depends only on the recovery of the carrier. In the determination of cesium-137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 5.

TABLE 5.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK[a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium–89	± 25%	± 20%	± 15%
Strontium–90	± 15%	± 10%	± 10%
Iodine–131	± 50%	± 20%	± 10%
Cesium–137	± 60%	± 25%	± 10%

[a] All errors are 2σ values, representing 95 percent confidence.

TABLE 6.—RADIONUCLIDES IN CANADIAN WHOLE MILK, DECEMBER 1963

[Radionuclide concentration in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89	Strontium-90	Cesium-137
Calgary	0.94	1.5	12	52.6	292
Edmonton	1.33	1.6	3	37.5	233
Ft. William	1.28	1.6	13	49.1	283
Fredericton	1.32	1.6	6	57.0	358
Halifax	1.28	1.6	8	37.7	271
Montreal	1.23	1.7	11	38.7	275
Ottawa	1.23	1.6	5	33.1	229
Quebec	1.25	1.6	8	45.7	328
Regina	1.28	1.5	8	52.2	208
St. John's Nfld.	1.25	1.5	10	48.0	274
Saskatoon	1.29	1.6	15	48.2	210
Sault Ste. Marie	1.28	1.7	8	36.9	226
Toronto	1.28	1.6	4	17.7	136
Vancouver	1.33	1.6	7	32.5	272
Windsor	1.16	1.6	3	17.5	101
Winnipeg	1.24	1.7	7	43.1	221
Average	1.25	1.6	8	40.5	245

Results

Table 6 presents monthly averages of strontium-89, strontium-90, cesium-137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 indicate that all samples had <5 pc/liter. Figure 7 shows the variation of the network average of the radionuclide concentration in Canadian whole milk.

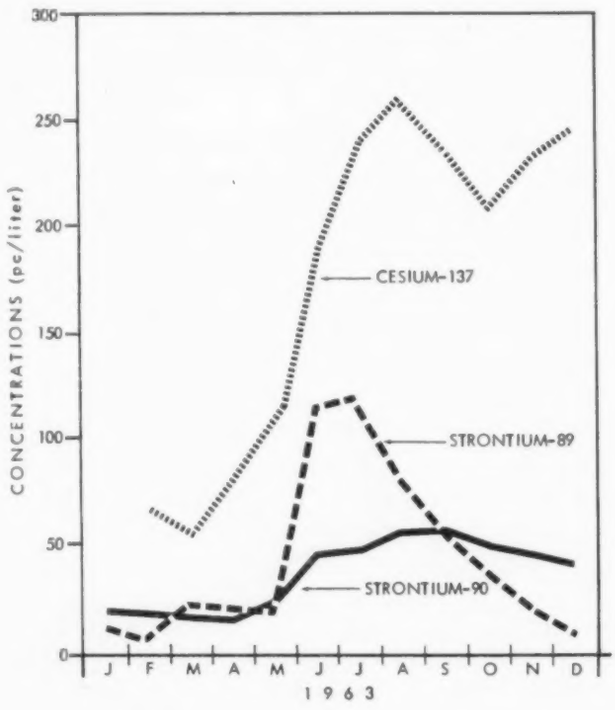

FIGURE 7.—NETWORK AVERAGE STRONTIUM-89, STRONTIUM-90 AND CESIUM-137 CONCENTRATIONS IN CANADIAN WHOLE MILK

Discussion

It should be emphasized that the interpretation of fallout data in relation to health is a complex problem. In comparing the concentration levels in a particular medium with the Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*4*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period such as one year represent a better basis for comparison than do individual levels at any specific time.

4. Radiostrontium in Milk,[3] July-September 1963

Health and Safety Laboratory
U. S. Atomic Energy Commission

The Health and Safety Laboratory began monitoring liquid whole milk in New York City in 1954 for strontium-90 in order to estimate the dietary contribution of this radionuclide from milk. Subsequently, powdered milk monitoring was initiated at Perry, New York, in 1954 and at Mandan, North Dakota in 1955. Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu samples are monthly composites of quart samples of pasteurized milk collected weekly. Samples from two dairies are analyzed and the results are averaged. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used in cattle feeds. Because of its protein and fat content, this buttermilk powder is used primarily as a milk replacer or feed supplement for calves. The Perry sample is powdered whole milk used for human consumption. The source of the Honolulu milk is from the island of Oahu where the

[3] Data summarized from AEC's *Fallout Program Quarterly Summary Report, HASL-142*:173-80, Office of Technical Services, U. S. Department of Commerce, Washington, D. C. 20230 (January 1, 1964), price $4.00.

TABLE 7.—STRONTIUM-90 AND CALCIUM IN MILK, JULY-SEPTEMBER 1963

Sampling station and period	Calcium (g/kg)	Strontium-90 (pc/kg)	Strontium-90 (pc/g Ca)
Liquid Milk			
New York City			
1963 Second Quarter			31.7
July	1.04	37.3	35.8
August	1.03	41.8	40.5
September	1.04	28.2	27.1
Honolulu, Hawaii			
1963 Second Quarter			9.0
July	1.10	9.8	9.0
August	1.08	8.3	7.6
September	1.12	8.3	7.4
Powdered Milk			
Perry, New York			
1963 Second Quarter			20.2
July	9.1	274	30.1
August	8.8	238	27.1
September	8.9	274	30.6
Powdered Buttermilk			
Mandan, North Dakota			
1963 Second Quarter			68.0
July	15.1	805	53.2
August	13.9	822	59.2
September	12.5	762	61.0

cows are on pasture throughout the year, and it is of interest to know how closely the strontium levels in milk in this area reflect changes in deposition rates.

The calcium and strontium-90 data are presented in table 7. The fluctuations of strontium-90 with time are shown in figures 8 and 9.

Comment

A marked increase in the strontium-90 content of milk from the continental U. S. stations was observed beginning in May 1963, due to the heavy spring fallout deposition. It is apparent from figures 8 and 9 that the peak strontium-90 concentrations were reached during the summer months.

The Honolulu milk samples still contain less strontium-90 per liter than those of other sampling stations, although there was a slight numerical increase in strontium-90 concentrations in the Honolulu samples in May also.

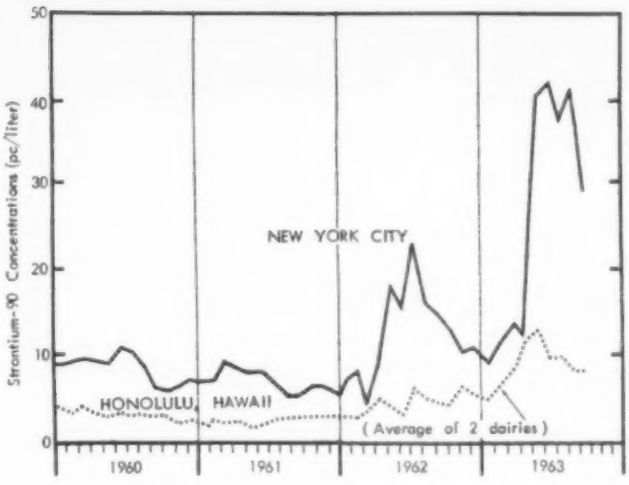

FIGURE 8.—STRONTIUM-90 IN LIQUID MILK SAMPLES

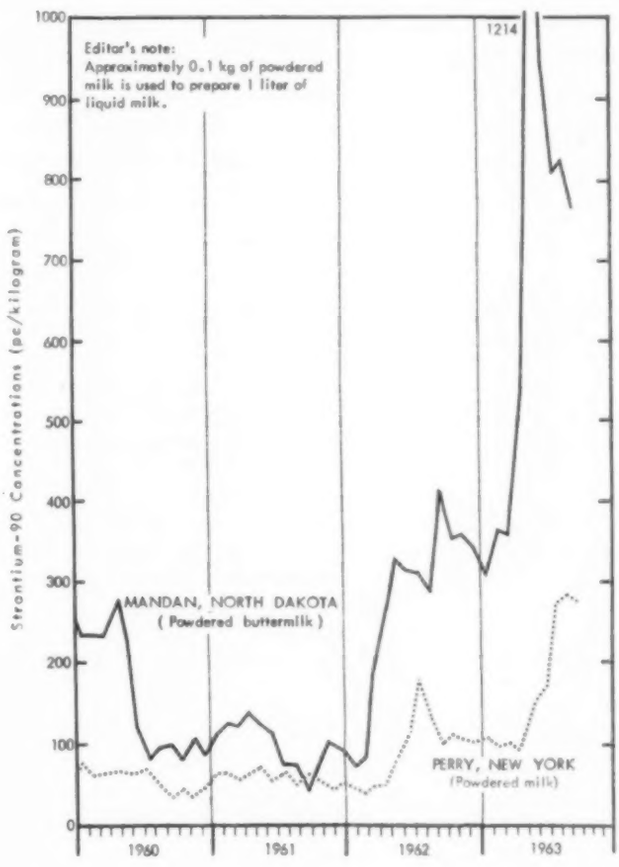

FIGURE 9.—STRONTIUM-90 IN POWDERED MILK SAMPLES

REFERENCES

(*1*) Public Health Service: Summary of Results from the Raw Milk Sampling Program, June 1957-April 1963, *Radiological Health Data*, *4*:511-23 (October 1963).

(*2*) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry*, *33*:1306-8 (September 1961).

(*3*) DasGupta, A. K., and H. G. Green: *A Method for Radiochemical Determination of Iodine-131 in Milk, RPD-23*, Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (October 1963).

(*4*) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

Recent coverage in *Radiological Health Data:*

Period	Issue
January-February 1962	*September 1962*
March-June 1962	*January 1963*
July-September 1962	*April 1963*
October 1962-March 1963	*October 1963*
April-June 1963	*January 1964*

MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, JANUARY-DECEMBER 1963

Division of Radiological Health, Public Health Service

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) can be used to assess the contribution of milk to an individual's or a population's radiation exposure. This is done by determining both the annual average concentrations of specific radionuclides in milk and the average daily milk consumption of an individual or a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium-89, strontium-90, iodine-131 and cesium-137 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*2, 3*).

To arrive at a basis of comparison between the daily rates of intake of the radionuclides from the milk component of the diet and the Federal Radiation Council's ranges of transient daily rates of intake (*4*), it is assumed that the average daily milk consumption of an individual in a population group is one liter. The Guides, however, apply to total intake from all foods. The upper limits of intake Range II correspond to the Radiation Protection Guide (RPG) for iodine-131 and one-third of the Radiation Protection Guide for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). However, the FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*). The ICRP has set the maximum permissible concentration (MPC) for cesium-137 in water for the population at large equal to 2000 pc/liter (*7*). This MPC may be applied to milk if it is assumed that all food would be contaminated to the same extent.

Annual averages of radionuclide concentrations in milk sampled by the PHS Pasteurized Milk Network are presented in table 1. The data in table 1 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged; (b) the averages for all weeks ending in twelve consecutive months are averaged to obtain the annual average.[1] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3, 4*).

Monthly variations of radionuclide concentrations in milk are due to a number of combined causes. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

REFERENCES

(*1*) Public Health Service: Milk Surveillance—Pasteurized Milk Network, *Radiological Health Data, 5*: 57 (February 1964).

(*2*) Bureau of the Census, and Public Health Service: National Food Consumption Survey, Fresh Whole Milk Consumption in the United States, July 1962, *Radiological Health Data* 4:15-17 (January 1963).

(*3*) Bureau of the Census and Public Health Service: Consumption of Selected Food Items in U. S. Households, July 1962, *Radiological Health Data, 4*:124-7 (March 1963).

(*4*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, *Federal Register*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (September 26, 1961).

(*5*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (September 1961), price 20 cents.

(*6*) Public Health Service: Special Report, *Radiological Health Data, 3*:ii-iii (September 1962).

(*7*) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

[1] Beginning with the October 1963 data, iodine-131 values of <10 pc/liter are considered to be zero for averaging purposes; previously 5 pc/liter was used in calculating the average.

TABLE 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		December [a] 1962 November 1963	January [b] 1963 December 1963	December [a] 1962 November 1963	January [b] 1963 December 1963	December [a] 1962 November 1963	January [b] 1963 December 1963	December [a] 1962 November 1963	January [b] 1963 December 1963
Ala:	Montgomery	64	59	20	21	9	4	72	76
Alaska:	Palmer	33	30	19	21	8	5	108	117
Ariz:	Phoenix	14	12	4	4	6	4	22	22
Ark:	Little Rock	125	111	41	42	24	8	143	148
Calif:	Sacramento	39	38	9	10	7	6	55	58
	San Francisco	73	71	13	13	8	5	65	70
Colo:	Denver	26	26	16	16	7	6	81	83
Conn:	Hartford	23	21	21	23	5	4	133	143
Del:	Wilmington	30	28	24	25	8	4	115	121
D. C:	Washington	40	38	19	19	7	4	89	92
Fla:	Tampa	33	30	14	14	11	6	206	215
Ga:	Atlanta	89	83	28	29	14	5	131	137
Hawaii:	Honolulu	36	34	10	10	9	6	69	73
Idaho:	Idaho Falls	43	43	22	23	7	5	121	131
Ill:	Chicago	21	18	19	20	6	4	96	101
Ind:	Indianapolis	31	28	21	23	9	4	88	93
Iowa:	Des Moines	60	57	23	24	12	5	82	87
Kans:	Wichita	44	41	18	19	12	5	69	70
Ky:	Louisville	91	84	31	32	9	4	97	102
La:	New Orleans	141	135	40	42	19	8	142	147
Maine:	Portland	26	26	28	30	5	4	179	191
Md:	Baltimore	48	46	20	21	7	4	109	116
Mass:	Boston	32	31	31	33	5	4	192	206
Mich:	Detroit	17	16	19	20	6	4	101	105
	Grand Rapids	19	18	19	20	7	5	104	110
Minn:	Minneapolis	49	48	27	29	7	5	135	142
Miss:	Jackson	139	127	34	35	17	7	102	108
Mo:	Kansas City	73	65	25	26	16	4	74	78
	St. Louis	50	47	21	21	8	5	77	82
Mont:	Helena	48	46	25	26	14	5	149	160
Nebr:	Omaha	51	49	24	24	16	5	89	92
Nev:	Las Vegas	19	17	8	8	5	4	61	65
N. H:	Manchester	29	29	30	32	6	5	215	230
N. J:	Trenton	22	21	20	21	6	4	107	113
N. Mex:	Albuquerque	23	21	9	9	8	4	39	41
N.Y:	Buffalo	22	21	21	22	5	4	121	128
	New York	30	29	27	28	6	4	135	147
	Syracuse	25	24	22	23	5	4	113	122
N. C:	Charlotte	67	65	30	31	6	4	108	114
N. Dak:	Minot	81	82	44	47	5	5	123	130
Ohio:	Cincinnati	39	35	24	25	10	5	79	84
	Cleveland	25	23	20	21	7	4	95	100
Okla:	Oklahoma City	69	62	22	23	21	6	82	85
Ore:	Portland	83	71	27	28	9	4	143	150
Pa:	Philadelphia	28	26	22	23	7	4	108	115
	Pittsburgh	36	33	26	28	9	4	130	137
P. R:	San Juan	79	69	14	14	14	8	87	88
R. I:	Providence	26	26	25	26	6	4	142	151
S. C:	Charleston	69	63	26	26	13	6	114	118
S. Dak:	Rapid City	67	65	33	35	9	5	131	139
Tenn:	Chattanooga	110	100	35	36	10	4	127	133
	Memphis	96	87	30	31	14	5	81	84
Tex:	Austin	36	30	9	9	24	6	45	44
	Dallas	85	68	20	21	38	7	77	78
Utah:	Salt Lake City	34	33	20	22	8	6	135	145
Vt:	Burlington	27	25	25	27	4	4	149	161
Va:	Norfolk	47	45	22	22	7	4	94	97
Wash:	Seattle	59	56	24	24	8	5	141	145
	Spokane	50	49	24	25	7	5	125	132
W. Va:	Charleston	66	65	28	29	6	4	89	93
Wis:	Milwaukee	20	18	17	18	6	4	99	106
Wyo:	Laramie	40	38	20	21	5	4	113	115
Network average		50	47	22.7	23.7	10	5	108	114

[a] Annual averages were computed on basis of 53 weekly averages.
[b] Annual averages were computed on basis of 52 weekly averages.

RADIONUCLIDES IN DIETS FOR TEENAGERS, MAY 1962-NOVEMBER 1963

Division of Pharmacology, Food and Drug Administration

It has been estimated that among all age groups 16-19-year-old males need more food daily than any other segment of the U. S. population (*1*). Because of this, the Food and Drug Administration (FDA) chose this age group for a test of the maximum radionuclide intake of all population groups. As a basis for the test, the food plan used was that recommended by the U. S. Department of Agriculture (USDA) for a nutritionally adequate diet at moderate cost level for boys 16-19 years of age (*2*).

The FDA study of radionuclides in diets for teen-agers was begun on a pilot basis in May 1961 in the Washington, D. C. area. Since then, the program has been expanded to include 8 other cities—San Francisco, Minneapolis, St. Louis, Atlanta, Denver, Boston, Dallas, and Seattle.

By selecting the 16-19-year-old male, who daily needs 3,600 calories with adequate protein, minerals, and vitamins, compared with 3,200 calories and smaller amounts of nutrients needed by the "standard" man, the radionuclide intake in U. S. diets can be conservatively estimated. For the purposes of the sampling program, amounts of the foods selected from the 11 food groups of the USDA plan were proportioned according to the 1955 Household Food Consumption Survey (*3*).

PROCEDURES

To duplicate the diet of a 19-year-old male, a list of 82 different items of food and drink was prepared. Quarterly samples of these items, covering a two-week consumption period, were purchased from national food chain stores. Efforts were made to locate the sources of the food items and to arrange representatians in diet kitchens at each city in a manner basis as possible.

The food was prepared by professional dietitions in diet kitchens at each city in a manner comparable to domestic preparation procedures. The most acceptable home practices for washing, trimming, bone removal, and separation of wastes and cooking water were used. Meats, fish, and chicken were broiled before removing the bones. Some fruits and vegetables were prepared as raw servings while others were cooked. Canned foods and raw frozen fruits were used as is. Coffee and tea were brewed. Certain cereals, such as rice, oatmeal, and macaroni, were cooked in water. Representative portions of each food (including about 8 liters of drinking water) were homogenized into a slurry, and aliquots were analyzed for strontium-90 and cesium-137 at the nearest FDA District laboratory. A radiochemical technique followed by beta counting was employed for strontium-90 analysis and gamma spectroscopy was employed for cesium-137 analysis.

RESULTS

The quarterly strontium-90 and cesium-137 concentrations in the recommended diet are shown in tables 1 and 2 for each city sampled, as well as the quarterly average for all cities. Strontium-90 and cesium-137 results are plotted in figure 1.

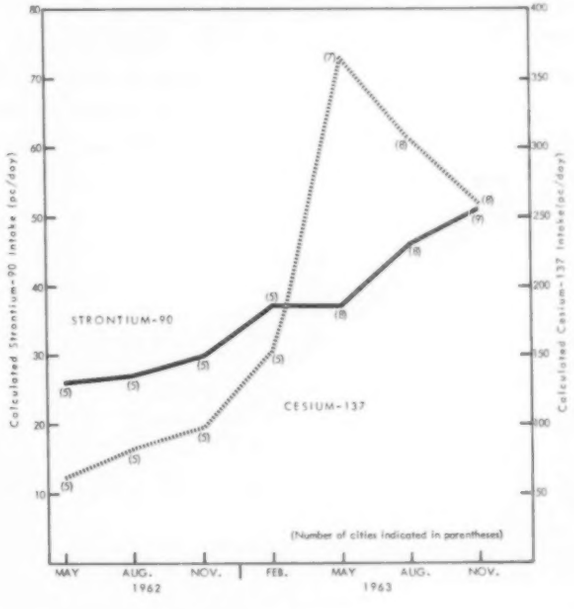

FIGURE 1.—AVERAGE STRONTIUM-90 AND CESIUM-137 CONCENTRATIONS IN TEEN-AGER TOTAL DIET

TABLE 1.—STRONTIUM-90 CONCENTRATIONS IN THE TOTAL DIET (Including Drinking Water), MAY 1962—NOVEMBER 1963

Sampling locations	May 1962		August 1962		November 1962		February 1963		May 1963		August 1963		November 1963	
	pc/kg	pc/day[a]	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day
Calif: San Francisco	3.0	11	3.4	13	4.8	18	8.0	30	9.4	35	5.7	21	6.4	24
Colo: Denver	[b]								7.5	28	7.5	28	10	38
D. C: Washington	6.4	24	6.9	26	8.4	32	12	45	11	41	11	41	13	49
Ga: Atlanta	9.7	36	7.2	27	9.2	35	13	49	10	38	18	68	19	71
Mass: Boston													13	49
Minn: Minneapolis	5.2	20	9.0	34	7.9	30	8.8	33	10	38	18	68	15	56
Mo: St. Louis	10	38	8.8	33	9.5	36	7.1	27	8.5	32	17	64	16	60
Texas: Dallas									13	49	10	38	13	49
Wash: Seattle									10	38	10	38	16	60
Average	6.9	26	7.1	27	7.9	30	9.8	37	9.9	37	12.2	46	13.5	51

[a] Intakes are calculated using a consumption factor of 3.76 kg/day for the 16–19-year-old male (*3*).
[b] Blank indicates no sample collected.

Strontium-90

The calculated average strontium-90 intake in the diet can be seen from table 1 to have increased steadily from 26 pc/day in May 1962 to 51 pc/day for November 1963. The latter value represents about one-fourth of the top of Range II (200 pc/day) of transient rates of daily intake for strontium-90 as recommended by the Federal Radiation Council (*4*).

Cesium-137

Table 2 shows that the calculated average cesium-137 intake in the diet increased from 62 pc/day in May 1962 to a peak of 366 pc/day in May 1963 and then decreased to 306 pc/day in August 1963 and 260 pc/day in November 1963. The Federal Radiation Council has not issued guidance for daily cesium-137 intake, since existing protection guides were deemed to be appropriate (*5*). If the 168-hour maximum permissible concentration in water for cesium-137 given by the National Committee on Radiation Protection in National Bureau of Standards Handbook 69 (*6*) is divided by 100 and a daily intake of two liters of water is assumed, a general population cesium-137 intake guide of about 4000 pc/day can be calculated. The value of 366 pc/day represents less than one-tenth of this calculated cesium-137 intake guide.

REFERENCES

(*1*) The National Academy of Sciences—National Research Council: *Recommended Dietary Allowances*, National Research Council Publication 589, Revised (1958).

(*2*) U. S. Department of Agriculture: *Family Food Plans and Food Costs, Home Economics Research Report No. 20*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (November 1962), price 35 cents.

(*3*) U. S. Department of Agriculture: *Food Consumption of Households in the United States, Report No. 1 (1955)*, Household Food Consumption Survey, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (December 1956), price $1.25.

TABLE 2.—CESIUM-137 CONCENTRATIONS IN THE TOTAL DIET (Including Drinking Water), MAY 1962—NOVEMBER 1963

Sampling locations	May 1962		August 1962		November 1962		February 1963		May 1963		August 1963		November 1963	
	pc/kg	pc/day[a]	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day
Calif: San Francisco	1.0	3.8	14	53	9.0	34	16	60	76	286	42	158	57	214
Colo: Denver	[b]								79	297	94	354	57	214
D. C: Washington	12	45	39	142	37	139	51	192	73	272	74	278	55	207
Ga: Atlanta	29	109	16	60	23	86	46	173	128	481	78	293	63	237
Mass: Boston													99	372
Minn: Minneapolis	13	49	31	112	28	105	62	223	114	427	109	410	83	312
Mo: St. Louis	33	124	13	49	34	128	31	112			80	300		
Texas: Dallas									100	376	68	256	44	165
Wash: Seattle									113	425	106	398	95	357
Average	17.6	62	23	83	26.2	98	41	152	98	366	81	306	69	260

[a] Intakes are calculated using a consumption factor of 3.76 kg/day for the 16–19-year-old male (*3*).
[b] Blank indicates no sample collected.

(4) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (September 1961), price 20 cents.

(5) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, *Federal Register*, pp. 4402-3 (May 18, 1960).

(6) National Committee on Radiation Protection: *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure, National Bureau of Standards Handbook 69*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (June 5, 1959), Price 35 cents.

Previous coverage in *RHD:*

Period	Issue
May 1961-August 1962	*January 1963*
May 1962-February 1963	*June 1963*

Section III.—Water

RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, OCTOBER 1963

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service Water Pollution Surveillance System (formerly National Water Quality Network) since its initiation in 1957. Beginning with the establishment of 50 sampling points, this System has expanded to 128 stations as of March 1, 1964. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the System provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the System are published in an annual compilation (*1-6*).

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them to the Public Health Service laboratory in Cincinnati for analysis. Determinations of gross alpha and gross beta radioactivity in the suspended and dissolved solids and of strontium-90 activity in the total solids are carried out on frequency schedules based on need.

Gross beta activity in each weekly sample was determined until January 1960, when the levels became essentially equal to background. Thereafter, gross beta determinations were made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established System stations. (Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.) On September 1, 1961, weekly determinations of gross beta activity again were instituted to permit early detection of activity due to fallout from renewed weapons testing. This practice was continued until the end of October 1962, when samples for gross beta analysis were again composited monthly. Gross alpha determinations were made once a month except where variable or high values observed during the first year indicated the need for more frequent measurement.

Normally, samples are counted at the Cincinnati Laboratory within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample when the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, OCTOBER 1963

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*7*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Since the fourth quarter of 1958, strontium-90 analyses have been made on three-month composites of aliquots from weekly samples. Beginning November 1962 the frequency of strontium-90 analyses was reduced to twice a year at each sampling point except those stations immediately below nuclear installations. Until the fourth quarter of 1961, the method used for determining strontium-90 was that described in the above reference (*7*). Tributyl phosphate was used to extract ingrown yttrium-90 from the purified, coprecipitated strontium-90. Beginning with the first quarter of 1962, a modification of a procedure described by Harley has been used (*8*). The yttrium-90, together with an yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background, anticoincidence, end-window proportional counter.

Results

Table 1 presents October 1963 results of alpha and beta analyses of U. S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first station listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples, as well as some analyses incomplete at the time of this report, will be included in the System's Annual Compilation of Data (*6*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter, with the exception that when all samples have zero pc/liter the mean is reported as zero. When the

TABLE 1.—RADIOACTIVITY IN SURFACE WATERS, OCTOBER 1963

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsburgh, Pa	2	12	14	0	1	1
Animas River:						
Cedar Hill, N. Mex	5	13	18	0	3	3
Apalachicola River:						
Chattahoochee, Fla	5	9	14	0	0	0
Arkansas River:						
Coolidge, Kansas	3	31	34	0	33	33
Ponca City, Okla	239	34	273	7	0	7
Fort Smith, Ark	69	56	125	6	3	9
Little Rock, Ark	13	32	45	2	1	3
Pendleton Ferry, Ark	24	41	65	1	5	6
Big Horn River:						
Hardin, Mont	16	36	52	2	8	10
Big Sioux River:						
Sioux Falls, S. Dak	19	59	78	1	3	4
Chattahoochee River:						
Atlanta, Ga	3	8	11	0	0	0
Columbus, Ga	1	8	9	0	0	0
Lanett, Ala	3	8	11	0	0	0
Chena Slough:						
Fairbanks, Alaska	1	5	6	0	0	0
Clearwater River:						
Lewiston, Idaho	7	11	18	0	0	0
Clinch River:						
Clinton, Tenn	2	10	12	0	<1	<1
Kingston, Tenn	29	42	71	<1	0	<1
Colorado River:						
Loma, Colo	56	41	97	11	12	23
Page, Ariz	2	37	39	0	7	7
Boulder City, Nev	0	19	19	0	7	7
Parker Dam, Calif-Ariz	2	15	17	0	10	10
Yuma, Ariz	0	43	43	0	7	7
Columbia River:						
Northport, Wash	5	15	20	0	1	1
Wenatchee, Wash	0	17	17	0	0	0
Pasco, Wash	132	770	902	0	0	0
McNary Dam, Ore	37	430	467	0	1	1
Bonneville, Ore	11	194	205	0	0	0
Clatskanie, Ore	14	138	152	0	<1	<1
Cumberland River:						
Clarksville, Tenn	2	11	13	0	0	0
Connecticut River:						
Wilder, Vt	7	17	24	0	0	0
Northfield, Mass	7	19	26	0	0	0
Enfield Dam, Conn	21	12	33	0	0	0
Cuyahoga River:						
Cleveland, Ohio	3	41	44	1	5	6
Delaware River:						
Martins Creek, Pa	2	15	17	0	0	0
Trenton, N. J	2	12	14	0	1	1
Philadelphia, Pa	17	16	33	1	0	1
Escambia River:						
Century, Fla	3	10	13	0	0	0
Great Lakes:						
Duluth, Minn	2	9	11	0	0	0
Sault Ste. Marie, Mich	0	10	10	0	1	0
Gary, Ind	4	5	9	0	1	1
Port Huron, Mich	1	8	9	0	0	0
Detroit, Mich	0	7	7	0	0	0
Buffalo, N. Y	9	14	23	1	0	1
Milwaukee, Wis	2	7	9	0	0	0
Green River:						
Dutch John, Utah	1	16	17	0	0	0
Hudson River:						
Poughkeepsie, N. Y	3	26	29	0	1	1
Illinois River:						
Peoria, Ill	7	32	39	1	2	3
Grafton, Ill	13	31	44	1	2	3
Kanawha River:						
Winfield Dam, W. Va	4	18	22	0	0	0
Klamath River:						
Keno, Ore	5	19	24	0	0	0
Kansas River:						
De Soto, Kans	158	45	203	9	2	11
Maumee River:						
Toledo, Ohio	5	21	26	1	0	1
Little Miami River:						
Cincinnati, Ohio	14	16	30	0	1	1
Merrimack River:						
Lowell, Mass	11	18	29	1	0	1
Mississippi River:						
St. Paul, Minn	7	29	36	0	4	4
Dubuque, Iowa	6	24	30	0	1	1
Burlington, Iowa	4	27	31	0	2	2
E. St. Louis, Ill	17	24	41	1	1	2
Cape Girardeau, Mo	17	32	49	2	2	4
W. Memphis, Ark	2	22	24	0	2	2
Vicksburg, Miss	8	25	33	1	3	4
Delta, La	8	26	34	1	2	3
New Orleans, La	1	37	38	0	2	2
Missouri River:						
Williston, N. Dak	8	42	50	0	7	7
Bismarck, N. Dak	4	29	33	1	6	7
Yankton, S. Dak	4	27	31	0	3	3
Omaha, Nebr	16	26	42	3	7	10
St. Joseph, Mo	18	18	36	3	2	5
Kansas City, Kans	17	21	38	4	3	7
Missouri River—Cont.						
Missouri City, Mo	10	22	32	1	2	3
St. Louis, Mo	23	22	45	3	2	5
Monongahela River:						
Pittsburgh, Pa	0	17	17	0	1	1
North Platte River:						
Henry, Nebr	11	42	53	<1	25	26
Ohio River:						
Addison, Ohio	4	22	26	1	0	1
Huntington, W. Va	2	16	18	0	0	0
Cincinnati, Ohio	0	11	11	0	2	2
Louisville, Ky	0	24	24	0	0	0
Evansville, Ind	6	28	34	1	1	2
Cairo, Ill	0	21	21	1	0	1
Toronto, Ohio	2	20	22	1	0	1
Ouachita River:						
Bastrop, La	7	43	50	0	3	3
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	4	4	0	1	1
Platte River:						
Plattsmouth, Nebr	40	37	77	3	5	8
Potomac River:						
Williamsport, Md	1	17	18	0	0	0
Great Falls, Md	2	13	15	0	1	1
Washington, D. C	4	15	19	1	1	2
Rainy River:						
Baudette, Minn	11	43	54	0	1	1
International Falls, Minn	9	32	41	0	0	0
Red River, North:						
Grand Forks, N. Dak	8	51	59	0	2	2
Red River, South:						
Denison, Tex	3	59	62	0	0	0
Index, Ark	5	50	55	0	3	3
Bossier City, La	1	0	1	0	0	0
Alexandria, La	5	25	30	1	4	5
Rio Grande River:						
Alamosa, Colo	6	15	21	1	3	4
El Paso, Tex	3	27	30	0	7	7
Laredo, Tex	137	31	168	14	5	19
Brownsville, Tex	37	38	75	4	2	6
Roanoke River:						
John H. Kerr Resr/Dam, Va	4	20	24	0	0	0
Sabine River:						
Ruliff, Tex	10	17	27	1	0	1
Sacramento River:						
Courtland, Calif	3	8	11	0	0	0
San Joaquin River:						
Vernalis, Calif	11	24	35	2	3	5
San Juan River:						
Shiprock, N. Mex	13	27	40	13	18	21
St. Lawrence River:						
Massena, N. Y	5	12	17	0	0	0
Schuylkill River:						
Philadelphia, Pa	2	36	38	0	0	0
Savannah River:						
North Augusta, S. C	3	10	13	0	0	0
Port Wentworth, Ga	5	19	24	0	0	0
Shenandoah River:						
Berryville, Va	2	0	2	0	1	1
Ship Creek:						
Anchorage, Alaska	3	2	5	0	0	0
Snake River:						
Ice Harbor Dam, Wash	6	18	24	0	2	2
Wawawai, Wash	0	17	17	0	2	2
Payette, Idaho	6	16	22	1	5	6
South Platte River:						
Julesburg, Colo	28	72	100	4	33	37
Spokane River:						
Post Falls, Idaho	0	7	7	0	0	0
Susquehanna River:						
Sayre, Pa	4	15	19	0	0	0
Conowingo, Md	6	21	27	0	0	0
Tennessee River:						
Lenoir City, Tenn	5	9	14	0	1	1
Chattanooga, Tenn	2	14	16	<1	0	<1
Bridgeport, Ala	5	19	24	0	0	0
Pickwick Landing, Tenn	3	21	24	0	0	0
Tombigbee River:						
Columbus, Miss	7	8	15	1	0	1
Truckee River:						
Farad, Calif	2	12	14	0	0	0
Verdigris River:						
Nowata, Okla	0	24	24	0	0	0
Wabash River:						
New Harmony, Ind	20	12	32	2	1	3
Willamette River:						
Portland, Ore	0	6	6	0	0	0
Yakima River:						
Richland, Wash	2	15	17	0	2	2
Yellowstone River:						
Sidney, Mont	26	37	63	5	4	9
Maximum	239	770	902	14	33	37
Minimum	0	0	1	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the network's Annual Compilation of Data (*6*).

calculated mean is between zero and 0.5 the mean is reported as < 1 pc/liter. The most recent quarterly strontium-90 results appeared in the January 1964 *RHD* (*9*).

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the October 1963 average total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Results for the years 1957-1962 have been summarized by Weaver *et al* (*10*).

Discussion

On the Columbia River, the monthly dissolved beta activity averages were greater than 200 pc/liter. Of the six stations on the Columbia River, the four downstream from the Hanford Atomic Products Operations facility had averages of between 152 and 902 pc/liter. It can be observed that the concentration diminishes with distance downstream from the facility.

While there are no generally applicable standards for surface water, the radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*11*). The Public Health Service Drinking Water Standards state that in the absence of strontium-90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1000 pc/liter (*12*).

REFERENCES

(*1*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data, PHS Publication No. 663*, 1958 Edition, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. Prince $1.50.

(*2*) *Ibid.*, 1959 Edition. Price $1.75.

(*3*) *Ibid.*, 1960 Edition.[2]

(*4*) *Ibid.*, 1961 Edition.[2]

(*5*) *Ibid.*, 1962 Edition.[2]

(*6*) *Ibid.*, 1963 Edition (in press).

(*7*) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).

(*8*) Harley, J. H.: Radiochemical Determination of Strontium-90, *Health and Safety Laboratory Manual of Standard Procedures*, August 1962 Revision, Radiochemistry and Environmental Studies Division, U. S. Atomic Energy Commission, New York Operations Office (1962).

(*9*) Public Health Service: National Water Quality Network, July 1963, *Radiological Health Data*, *5*: 31-35, (January 1964).

(*10*) Weaver, L., A. W. Hoadley, and S. Baker: Radioactivity in Surface Waters of the United States, 1957-1962, *Radiological Health Data*, *4*:306-16, (June 1963).

(*11*) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association* *53*:704 (June 1961).

(*12*) Public Health Service: *Drinking Water Standards, Revised 1962, Public Health Service Publication No. 956*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (March 1963), price 30 cents.

[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium-90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D. C. 20201.

RADIOSTRONTIUM IN TAP WATER, MAY-OCTOBER 1963[1]

Health and Safety Laboratory
U. S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. At Richmond, California, the sampling of tap water was begun in April 1958 and continued through June 1963. Samples of tap water are collected daily at each site so that by the end of the month a composite of at least 100 liters is available for analysis. Also, determinations of strontium-89 have been made since September 1961. The analytical methods are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Data for the past several years are plotted in figure 1. Data prior to 1958 appear in an earlier HASL report (*2*). Strontium-90 con-

[1] Data taken from AEC Fallout Program Quarterly Summary Report, *HASL-142*:173-80, Office of Technical Services, U. S. Department of Commerce, Washington, D. C. 20230 (January 1, 1964), price $4.00.

centrations and strontium-89/strontium-90 ratios for May through October 1963 appear in table 1.

Monthly average strontium-90 concentrations in tap water at New York City increased to 2.14 pc/liter in July 1963. Thereafter the trend was one of decreasing levels. Although the levels at Richmond, California are normally lower than those observed in New York City, the data for Richmond show that levels there were also increasing during the spring of 1963.

The strontium-89/strontium-90 ratios indicate that the fallout was probably not of any more recent origin when strontium-90 concentrations were high than when they were low.

The maximum strontium-90 concentrations observed are below the acceptable limit of 10 pc/liter as set forth in the interstate carrier drinking water standards (*3*).

TABLE 1.—RADIOSTRONTIUM IN TAP WATER

Month 1963	New York City[a]		Richmond, California[b]	
	Sr^{90} (pc/liter)	Sr^{89}/Sr^{90}	Sr^{90} (pc/liter)	Sr^{89}/Sr^{90}
May	1.23	3.9	0.50	3.8
June	1.23	3.3	0.82	1.9
July	2.14	2.2	[d]	[d]
August	1.76	[c]		
September	1.88	[c]		
October	1.40	[c]		

Note: Strontium–89 extrapolated to midpoint of sampling period.
[a] From 100–200 liters per sample.
[b] Approximately 100 liters per sample.
[c] Strontium–89 analyses not performed.
[d] Sampling discontinued.

REFERENCES

(*1*) U. S. Atomic Energy Commission: *Manual of Standard Procedures*, *40*:E-38-01-16, Health and Safety Laboratory, U. S. Atomic Energy Commission, 376 Hudson Street, New York 14, N. Y.

(*2*) U. S. Atomic Energy Commission: *Environmental Contamination from Weapons Tests, HASL-42*, Office

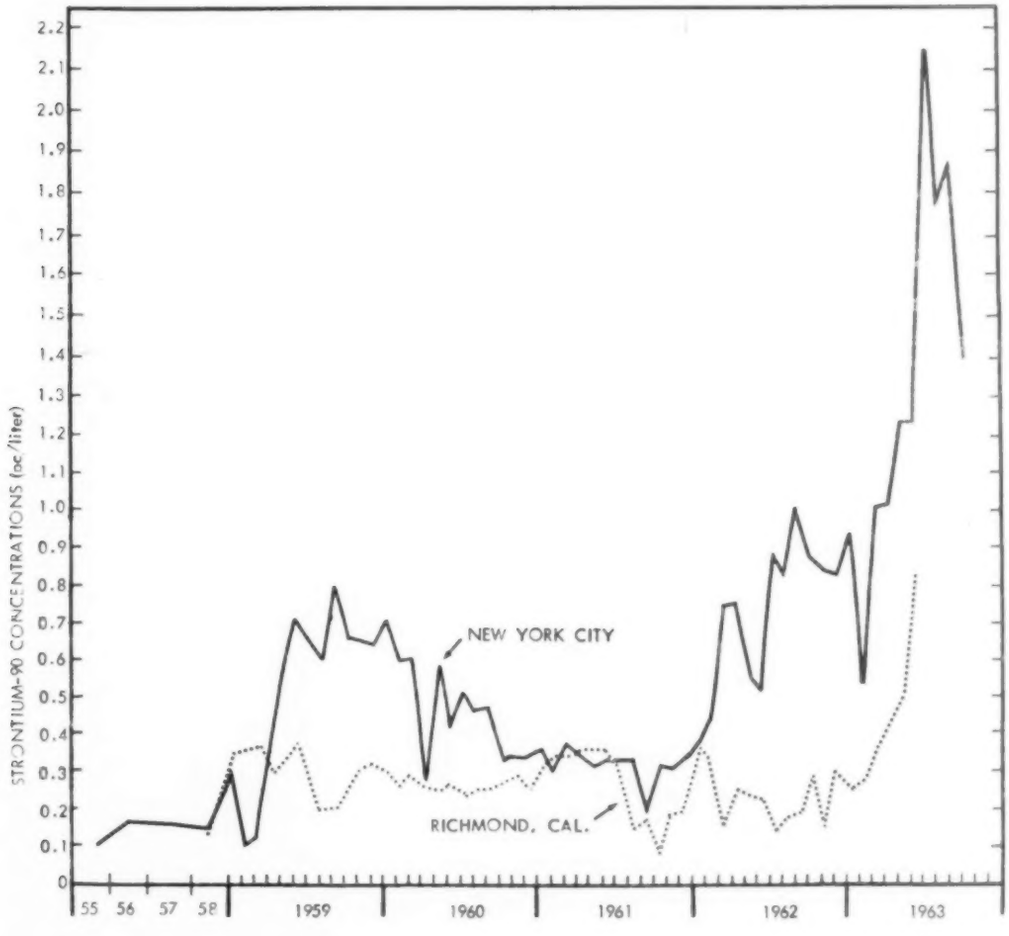

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN TAP WATER

of Technical Services, Department of Commerce, Washington, D. C. 20230, (October 1962), price $3.50.

(*3*) Federal Register Rules and Regulations: *Title 42—Public Health, Chapter 1*—Public Health Service, Department of Health, Education, and Welfare; Part 72, *Interstate Quarantine, Subpart J, Drinking Water Standards, 27*:2154-5, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (March 6, 1962).

Recent coverage in *Radiological Health Data:*

Period	Issue
Third and fourth quarters 1961	*June 1962*
January-April 1962	*September 1962*
March-June 1962	*January 1963*
July-December 1962	*July 1963*
January-April 1963	*January 1964*

Section IV.—Other Data

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *Radiological Health Data* since November 1960. Summaries follow for Bettis Atomic Power Laboratory and Mound Laboratory.

Releases of radioactive materials from these Laboratories for the periods covered in the reports below are regulated in accordance with standards set forth in the Federal Register Title 10 - Part 20. The appropriate concentration standards are given in table 1.

TABLE 1.—MAXIMUM PERMISSIBLE CONCENTRATIONS PERTAINING TO ENVIRONMENTAL MONITORING AT BETTIS ATOMIC POWER LABORATORY AND MOUND LABORATORY[a]

Radionuclide	Air (pc/m³)	Water (pc/liter)
Hydrogen-3 (tritium)	200,000	3,000,000
Strontium-90	10	100
Polonium-210	20	700
Uranium-natural	2	20,000
Plutonium-239	0.06	5,000

[a] The concentration standards given here were abstracted from the Atomic Energy Commission's regulation 10 CFR Part 20 (Federal Register, November 17, 1960).

1. Bettis Atomic Power Laboratory, July 1962-June 1963[1]

Westinghouse Electric Corporation

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and the central station atomic power reactor at Shippingport, Pennsylvania.

Effective July 1962, several changes were made in BAPL's environmental monitoring program as described below. The data for the 12-month period from July 1962 through June 1963 are given in table 2. Figure 1 shows the location of sampling sites for the revised program.

Liquid Radioactive Waste: The liquid effluent discharged from the Laboratory is sampled continuously and composite samples are analyzed weekly for gross alpha and gross beta-gamma activity and quarterly for strontium-90 beta activity, as in the past. In addition, an analysis for total uranium alpha activity will

[1] Data and information summarized from semi-annual reports to the Pennsylvania Department of Health entitled *Environmental Radioactivity at the Bettis Atomic Power Laboratory*: PNRO-DEV-122, July 12, 1962; PNRO-DEV-124, January 11, 1963; and PNRO-DEV-126, July 15, 1963. The reports were prepared by BAPL's Industrial Hygiene Department and transmitted through the AEC Pittsburgh Naval Reactors Office.

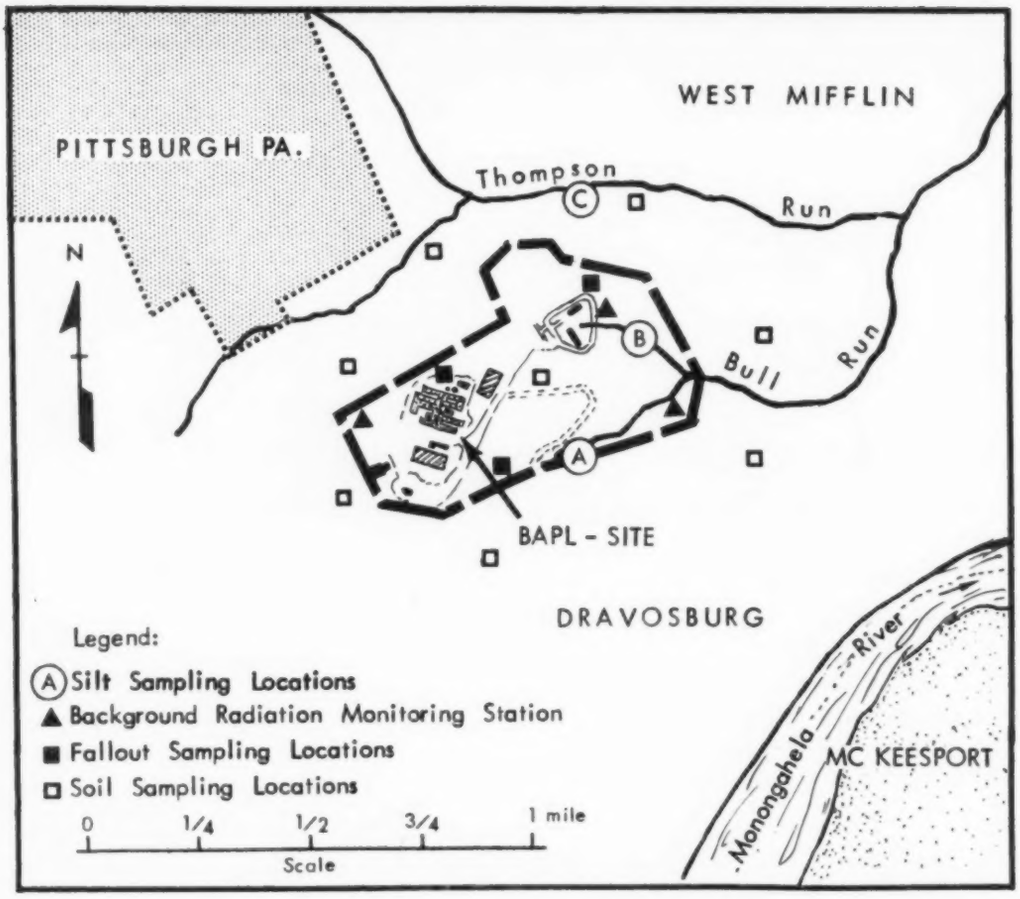

FIGURE 1.—BETTIS ATOMIC POWER LABORATORY SAMPLING STATIONS

be performed whenever the combined gross alpha and gross beta-gamma activities exceed 2×10^{-6} μc/cc.

Background Monitoring Stations: Four background monitoring stations (previously one) are in continuous operation on the Laboratory property. Three of the stations are located at the perimeter of the Laboratory and one station is centrally-located with respect to the main Laboratory area. These stations continually measure and record the external beta-gamma radiation level, the external gamma radiation level and the beta-gamma activity of particulates in air as collected by a continuous air monitor of the moving filter type. An air sample is continuously collected at two of the stations. The filters removed from the high volume air samplers are retained for specific analysis when required to identify the nature of the airborne activity. External gamma dose rates for the three perimeter stations are given in table 2.

TABLE 2.—RADIOACTIVITY IN THE BAPL ENVIRONMENT

Type of measurement	1962		1963	
	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter
Liquid wastes (pc/liter)				
Gross activity[a]	108	102	170	400
Strontium-90	1.1	5.2	7.1	[b]—
Beta-gamma dose rate (mrad/hr)		[c]0.027		[c]0.024
Beta activity in fallout (mc/mi²/mo)	128	130	76	210
Stream silt (pc/gm)				
Alpha: Station A	87	19	24	36
Station B	64	16	39	26
Station C	no sample	16	17	13
Beta: Station A	33	31	13	91
Station B	16	17	10	12
Station C	no sample	11	10	15

[a] An environmental MPC of 2000 pc/liter is used as the standard for liquid wastes effluent (see table 1).
[b] Second quarter 1963 strontium-90 analysis. The second quarter 1962 average was 1.0 pc/liter.
[c] Beta-gamma dose rate values are semi-annual averages.

Soil Samples: Soil Samples are collected at eight locations (previously eleven) on and off site and are retained for a period of two years. These samples will be analyzed for radioactivity only on an "as required" basis. No analyses were required during the 12-month period ending June 1963.

Stream Silt: Stream silt samples are collected quarterly at three locations (previously four) described as follows:

Location A: Bull Run downstream from the point where the water effluent leaves the main laboratory area at the first point where silt has accumulated.

Location B: C-Area effluent downstream from its origin at the first point where silt has accumulated.

Location C: Thompson Run downstream from the junction of the High Temperature Test Facility effluent and Thompson Run at the first point where silt has accumulated.

These samples are analyzed quarterly for gross alpha activity and gross beta-gamma activity. Table 2 shows that samples from location A tend to have slightly higher beta activity than B or C and both A and B tend to have higher alpha activities than C.

Fallout: Fallout samples are collected at three locations (previously eight) at the perimeter of the Laboratory. The samples are collected over a period of one month in high-wall stainless steel pots and are analyzed for gross alpha activity and gross beta-gamma activity.

Recent coverage in *RHD:*

Period	Issue
January to June 1961	*April 1962*
July 1961 to June 1962	*April 1963*

2. Mound Laboratory, July 1962-June 1963

Monsanto Research Corporation

Of the radionuclides in use at Mound Laboratory, only polonium-210, plutonium-239, and hydrogen-3 (tritium) are potential environmental contaminants. No measurable amounts of penetrating radiation such as gamma or hard beta have contributed to the environmental contamination by the Laboratory during the period covered by this report.

The environmental monitoring program, conducted by the Monsanto Research Corporation is planned and coordinated with regard to all of the various projects performed in the Laboratory. Water and air monitoring methods and results are discussed below.

Air Monitoring

A continuous air monitor for measurement of tritium and particulate air sampling equipment for measurement of alpha activity are mounted on a one-ton panel truck for use in the routine monitoring of the environmental air at 95 locations selected within a radius of 20 miles. The choice of sites on a given day depends on the wind direction at the time of collection.

During the 12-month period ending June 1963, 448 samples were taken for determination of tritium in air. In all cases tritium was nondetectable.

Monitoring for possible polonium-210 and plutonium-239 released to the environment is accomplished by determination of long-lived gross alpha on filter paper samples. Counting is done in a low-background proportional counter after sufficient time elapses after collection to permit the decay of short-lived daughter products of radon and thoron. The measured concentrations of alpha activity in air are summarized in table 3. No specific determinations of polonium-210 or plutonium-239 were made, since the alpha activity remained substantially below the environmental MPC's for these nuclides (see table 1). It may be observed that the largest difference between upwind and downwind average alpha activity

TABLE 3.—LONG LIVED ALPHA CONCENTRATIONS IN AIR IN THE MOUND LABORATORY ENVIRONMENT

[Average concentrations in pc/m³]

Direction from laboratory relative to wind	Third quarter 1962		Fourth quarter 1962		First half 1963	
	No. of samples	Alpha	No. of samples	Alpha	No. of samples	Alpha
Upwind	18	0.0014	18	0.0011	26	0.0034
Downwind	131	0.0029	115	0.0019	154	0.0030

is 0.0015 pc/m³ for third quarter 1962. If this were assumed to be due only to plutonium-239 it would represent 2.5 percent of the environmental MPC.

Water Monitoring

Liquid radioactive waste materials from polonium operations at the Laboratory are processed in a special waste disposal plant designed to reduce radioactivity to a concentration level at which it may be discharged to the Great Miami River (station 2, figure 2). Liquid waste from these activities is small in volume, is handled separately as a packaged waste, and is not discharged to the river. Helium-3, which is purified at the Mound Laboratory, yields small quantities of tritium. Liquid wastes from this work, also small in volume, are treated separately (diluted with water when necessary) to assure that the radioactive content is below the maximum permissible concentration for discharge to the Great Miami River.

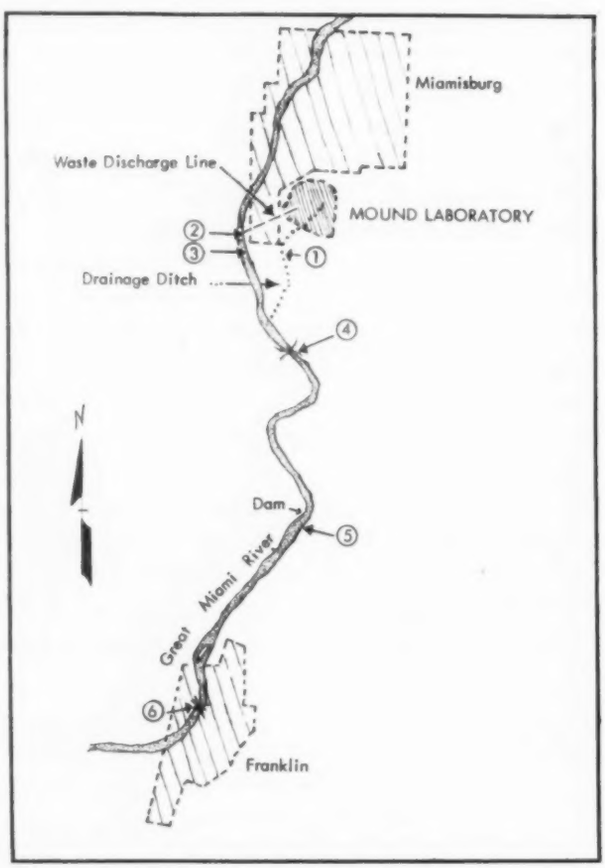

FIGURE 2.—WATER SAMPLING LOCATIONS IN GREAT MIAMI RIVER, MOUND LABORATORY

TABLE 4.—OFF-SITE WATER MONITORING FOR POLONIUM AND TRITIUM FROM MOUND LABORATORY[a]

[Average concentrations in pc/liter]

Nuclide and station number (see figure 2)	Third quarter 1962		Fourth quarter 1962		First half 1963	
	No. of samples	Concentration	No. of samples	Concentration	No. of samples	Concentration
Polonium-210						
2 (effluent)	9	0.7	8	31.3	15	45.0
3	9	2.0	8	6.5	15	1.1
4	9	1.6	8	2.9	15	0.9
5	9	1.0	8	0.0	15	0.4
6	9	1.8	8	0.7	15	0.0
Others[b]	6	0.0	6	2.1	0	—
Hydrogen-3 (tritium)						
1 (drainage ditch)	9	0	8	130,000	14	70,000
2 (effluent)	9	270,000	8	250,000	14	0
4	9	180,000	8	260,000	14	0

[a] See table 1 for applicable environmental MPC values.
[b] Single samples were collected quarterly from six locations downstream from Franklin.

Weekly water samples are collected from a drainage ditch and five locations along the Great Miami River as shown in figure 2. The drainage ditch carries away all storm sewer water and liquid tritium wastes from the plant site. Sampling location number 2 is located at the point of discharge of the laboratory effluent to the Great Miami River, and Number 6 is five miles downstream from the effluent discharge. Additional single downstream samples were collected at six locations (beyond the limits of the map in figure 2) during the third and fourth quarters of 1962.

All of the river samples are analyzed for polonium. The drainage ditch samples and some of the river samples are analyzed for tritium. Average concentrations of tritium and polonium are given in table 4. The highest polonium-210 concentration during the 12-month period was 180 pc/liter in a sample of Laboratory effluent (station 2) collected during the first half of 1963. This represents 26 percent of the MPC for polonium (see table 1). The highest value found in a tritium sample was 1,700,000 pc/liter or 34 percent of the MPC.

Recent coverage in *RHD:*

Period	Issue
January-June 1961	*January 1962*
July-December 1961	*June 1962*
January-June 1962	*March 1963*

REPORTED NUCLEAR DETONATIONS, MARCH 1964

During March 1964, the United States Atomic Energy Commission announced one nuclear detonation. This was a low yield underground detonation conducted on March 13, 1964 at the Nevada Test Site. Low yield range is defined as less than 20 kilotons. Arbitrary reference number 151 was assigned by *Radiological Health Data.*

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UNITS AND EQUIVALENTS

Symbol	Unit	Equivalent
Bev	billion electron volt	
cpm	count per minute	
dpm	disintegration per minute	
g	gram	
kg	kilogram	1 kg = 1000 gm = 2.2 pounds
km^2	square kilometer	
kvp	kilovolt peak	
m^3	cubic meter	1 m^3 = 1000 liters
ma	millampere	
mas	milliampere-second	
Mev	million electron volts	
mi^2	square mile	
ml	milliliter	
mm	millimeter	
mrad	millirad	
mrem	millirem	
mr/hr	milliroentgen per hour	
mμc	millimicrocurie	1 mμc = 1 nc
nc	nanocurie	1 nc = 1000 pc = 1 mμc = 10^{-9} curies
nc/m^2	nanocurie per square meter	1 nc/m^2 = 1 $mμc/m^2$ = 1,000 $μμc/m^2$ = 1 mc/km^2 = 2.59 mc/mi^2
pc	picocurie	1 pc = 1 μμc = 10^{-12} curies
r	roentgen	
μμc	micromicrocurie	1 μμc = 2.22 dpm

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr′ a
10^{9}	giga	G	jĭ′ ga
10^{6}	mega	M	mĕg′ a
10^{3}	kilo	k	kĭl′ o
10^{2}	hecto	h	hĕk′ to
10	deka	da	dĕk′ a
10^{-1}	deci	d	dĕs′ ĭ
10^{-2}	centi	c	sĕn′ tĭ
10^{-3}	milli	m	mĭl′ ĭ
10^{-6}	micro	μ	mī′ kro
10^{-9}	nano	n	năn′ o
10^{-12}	pico	p	pē′ co
10^{-15}	femto	f	fĕm′ to

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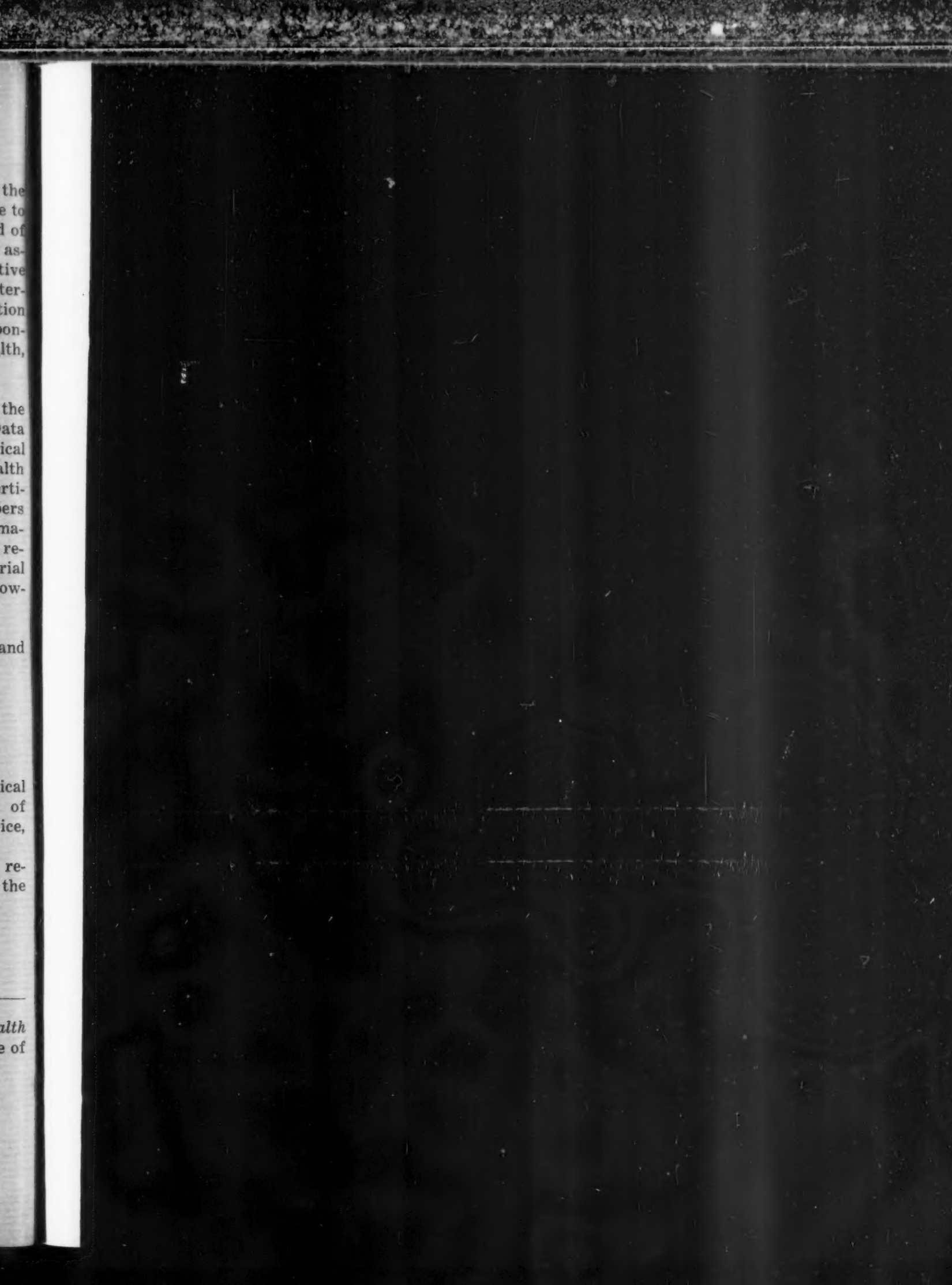
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